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STUDY REPORT
CAA-SR-89-18

# RETROGRADE TRANSPORTATION
# (RÉTRO II)

JANUARY 1990



PREPARED BY
FORCE SYSTEMS DIRECTORATE

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This study describes a methodology for incorporating the retrograde of damaged materiel within a theater of operations into a transportation workload within the force structure process.

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STUDY REPORT
CAA-SR-89-18

# RETROGRADE TRANSPORTATION (RETRO II)

January 1990

Prepared by


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DEPARTMENT OF THE ARMY
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REPLY TO
ATTENTION OF

CSCA-FSL/P (5-5d)

30 JAN 1990

MEMORANDUM FOR DEPUTY CHIEF OF STAFF FOR LOGISTICS, ATTN: DALO-PLA, WASHINGTON, DC 20310-0527

SUBJECT: Retrograde Transportation (RETRO II)

1. Reference memorandum, DALO-PLA, 31 May 1988, subject: Retrograde Transportation (RETRO II) Study.

2. Subject memorandum directed the U.S. Army Concepts Analysis Agency (CAA) to conduct a study to develop a methodology for determining the requirements and capabilities of the wartime transportation system to support the retrograde of non-operational Class VII and IX assets within the theater of operations.

3. This final report documents the results of our analysis and provides a framework for incorporating the calculation of retrograde transportation force structure requirements in Army theater models. The general methodology described in this study could also be used to incorporate other combat service support functions not presently modeled in the force structuring process.

4. CAA expresses appreciation to all commands and agencies which have contributed to this study. Questions and/or inquiries should be directed to the Assistant Director, Force Systems Directorate, U.S. Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, AUTOVON 295-1607.

E. B. Vandiver
E. B. VANDIVER III
Director

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| CAA | RETROGRADE TRANSPORTATION (RETRO II) STUDY | STUDY SUMMARY CAA-SR-89-18 |

**THE REASON FOR PERFORMING THE STUDY** was to develop a method of incorporating a workload (retrograde of damaged materiel within a theater of operations) not presently included in the process utilized for determining requirements for military transportation truck units within current force structure models.

**THE STUDY SPONSOR** was the Deputy Chief of Staff for Logistics, Headquarters, Department of the Army.

**THE STUDY OBJECTIVE** was to develop a methodology for estimating the impact of materiel retrograde on the wartime intratheater transportation requirements. The methodology was to be readily adaptable for inclusion in the Total Army Analysis force structure requirements process.

**THE SCOPE OF THE STUDY** was to examine the transport of retrograde materiel within the European theater of operations during the first 90 days of a potential conflict.

**THE MAIN ASSUMPTIONS** of this work are:

(1) Retrograde operations will begin on D-day.

(2) The priority of items to be retrograded will not significantly affect total retrograde transportation requirements.

(3) Corps transportation units transporting ammunition are dedicated to ammunition only by the Maneuver Oriented Ammunition Distribution System (MOADS) or MOADS/Palletized Loading System (PLS) doctrine.

(4) Railroad support is not forward of corps.

(5) Output from a combat simulation model such as the Concepts Evaluation Model (CEM) and the Force Analysis Simulation of Theatre Administrative and Logistic Support (FASTALS) Model will be available.

**THE BASIC APPROACH** used in this study was to examine the retrograde process along with models currently used to determine force structure. Results of this comparison were used to recommend changes to the force structure process that would allow the inclusion of retrograde-created transportation workloads in the process.

**THE PRINCIPAL FINDINGS** of the work reported herein are as follows:

(1) Retrograde can be included in the force structure process using maintenance data provided by current models.

(2) Combat damage determination within the models used to determine combat service support structure may need to be expanded to include more systems.

(3) Equipment densities need to be incorporated into the Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS) Model in order to support retrograde requirements determination.

(4) The methodology described in this study could be used to incorporate other combat service support functions not presently modeled in the force structuring process.

**THE STUDY EFFORT** was directed by MAJ Richard G. Poulos, Force Systems Directorate, US Army Concepts Analysis Agency (CAA).

**COMMENTS AND QUESTIONS** may be sent to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-FSL, 8120 Woodmont Avenue, Bethesda, Maryland 20814-2797.

*Tear-out copies of this synopsis are at back cover.*

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## TABLES

# CHAPTER 1

# EXECUTIVE SUMMARY

**1-1. PROBLEM.** The impact of materiel retrograde on wartime transportation system requirements and capabilities is not known.

**1-2. BACKGROUND.** The Army Materiel Command (AMC) by doctrine is required to provide backup direct support and general support maintenance for those items that cannot be repaired in the theater of operations due to a shortfall in maintenance capability. Recent studies, such as Estimation of FY 86 Workloads for Continental United States (CONUS) Wholesale Logistics Base (ESTIMATE-86), have provided estimates as to what that shortfall might be in terms of manhours by commodity. Retrograde materiel which cannot be repaired within the theater must be transported to a port area for eventual movement to the CONUS or another offshore location. Movement of retrograde materiel will have an impact on the current intratheater transportation system. At the present time, a method of estimating the impact of retrograde on the transportation system does not exist.

**1-3. OBJECTIVE.** The objective of this study was to develop a methodology for estimating the impact of materiel retrograde on the wartime intratheater transportation requirements. The methodology is to be readily adaptable for inclusion in the Total Army Analysis (TAA) force structure requirements process.

**1-4. SCOPE.** The study examines the transport of retrograde materiel within the European theater of operations during the first 90 days of war.

**1-5. LIMITATIONS**

**a.** There is a lack of guidance within Army regulations, field manuals, and other publications describing the current policies and procedures for the retrograde of materiel from a theater of operations during wartime.

**b.** Combat damage data for components is limited to equipment that has been evaluated by the Sustainability Predictions for Army Spare Component Requirements for Combat (SPARC) process.

**c.** The methodology is currently limited to those end items which are represented in the Concepts Evaluation Model (CEM).

**1-6. TIMEFRAME.** The 1996 force was utilized as the base wherever actual data, policies, and unit structure were required for use in this study.

**1-7. KEY ASSUMPTIONS**

**a.** Retrograde operations will begin on D-day.

**b.** The priority of items to be retrograded will not significantly affect total retrograde transportation requirements.

c. Corps transportation units transporting ammunition are dedicated to ammunition only by the Maneuver Oriented Ammunition Distribution System (MOADS) or MOADS/Palletized Loading System (PLS) doctrine.

d. Railroad support is not forward of corps.

## 1-8. STUDY APPROACH AND METHODOLOGY

a. Figure 1-1 displays the methodology used in this study. The basic approach employed in this study was to analyze doctrine as published in field manuals and other publications to identify those elements of the retrograde function to be represented in a retrograde model. Once the essential elements had been determined, current models and studies were examined to see how the retrograde, maintenance, and transportation functions were represented. Information collected was then examined to determine what elements of these functions were not represented and how the current force structure process should be changed to include the transportation workload created as a result of the retrograde function.

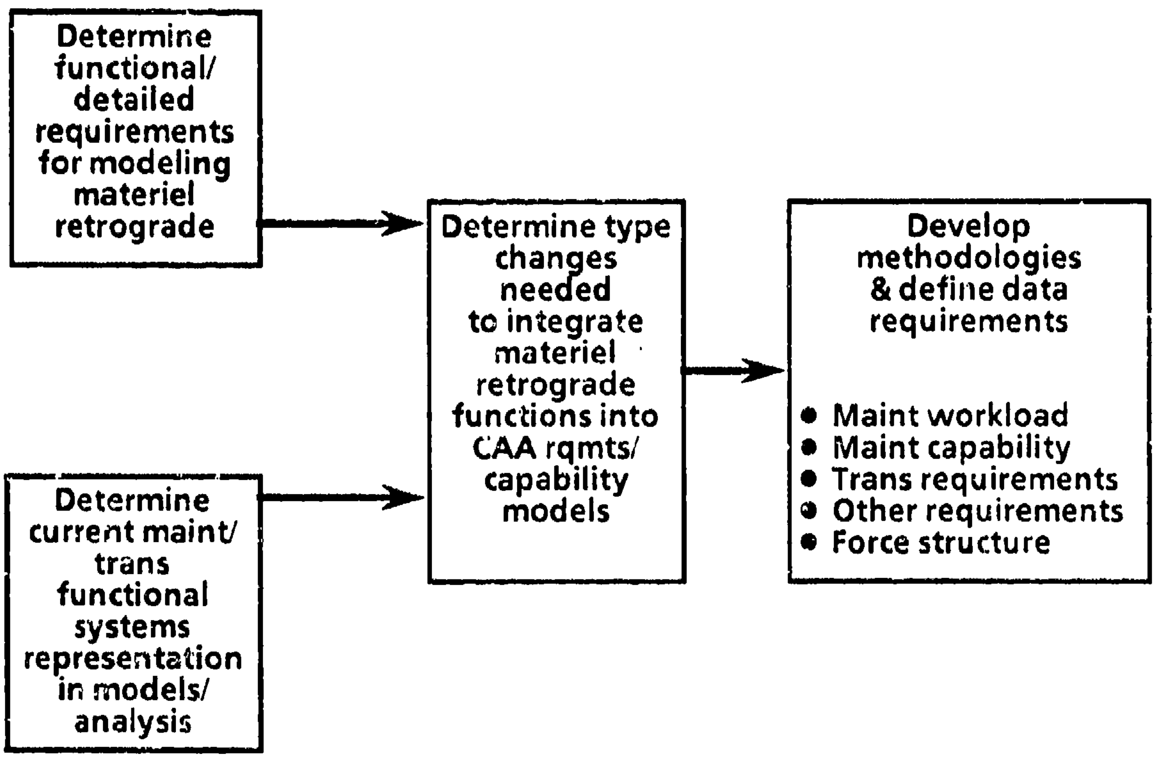


Figure 1-1. Study Methodology

**b.** A methodology was then developed to incorporate the retrograde of damaged materiel into the current theater transportation workload as represented in the force structure process. Data requirements and sources of the data were identified.

## 1-9. ESSENTIAL ELEMENTS OF ANALYSIS (EEA)

**a. How can the maintenance workload which drives retrograde requirements be quantified?**

**Answer:** By using the outputs from the CEM in combination with factors from the US Army Materiel Systems Analysis Activity (AMSAA), maintenance workloads in terms of components and end items can be determined.

**b. How can the wartime maintenance capability to handle retrograde-candidate materiel be quantified?**

**Answer:** Maintenance capability can be determined by multiplying units onhand, unit effectiveness, the number of personnel by military occupational specialty (MOS), and the number of effective hours per MOS per day by area, respectively.

**c. How can those maintenance shortfalls which generate retrograde transportation requirements be determined?**

**Answer:** Maintenance requirements by priority are compared to maintenance capabilities (see a and b above). Any resulting shortfall in capabilities will be defined as an evacuation/ retrograde requirement.

**d. How can the requirement to move retrograde materiel be included in the transportation workload within the theater?**

**Answer:** Retrograde requirements (shortfall), as discussed in the previous EEA, are converted into workloads (STON or end items). End items that do not require a heavy equipment transporter (HET) for transport and damaged components are converted to short ton equivalents for movement by medium truck units. End items requiring HETs for movement will make up the transportation workload requirements for HET units.

**e. How can wartime retrograde transportation requirements other than Class VII and IX maintenance shortfalls be estimated?**

**Answer:** Transportation workloads can be estimated for enemy prisoners of war, medical evacuation, unit moves, killed in action, and mail using the Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS) Model, OMNIBUS, tables of organization and equipment (TOE) files, and Field Manual 101-10-1. Rearward movement of supply stocks, captured enemy materiel, critical strategic materials, and materiel involved in denial operations cannot be estimated at this time. It is assumed that rearward movement of ammunition will be handled by those trucks not being utilized for retrograde on the basis of the assumption of paragraph 1-7d.

**f.** **How can the retrograde of materiel be represented in the present force structure?**

**Answer:**

(1) Forward moving transportation assets (units) will be considered as eligible to move retrograde when returning from a forward mission. The performance of this dual mission may have a negative impact on a transportation unit's primary mission capability. For example, delays due to offloading/loading, speed differentials, and location necessitating an adjustment to doctrinal (single mission) capability of the retrograde cargo may degrade forward capability.

(2) Net retrograde transportation capability can be determined by decrementing the total number of forward moving units by the number of dedicated transportation units (except ammunition as excluded by assumption 5) and by the negative impact of the dual mission on the remaining units.

(3) Net transportation capability is further reduced by adjusting the capability of transportation assets for requirements generated by other rearward moving materiel and personnel.

(4) Total retrograde transportation requirements can be determined in terms of transportation units required to support the retrograde function.

(5) These retrograde truck unit requirements are then offset by the net adjusted forward movement capability. Any shortfall in unit capability will constitute additional truck unit requirements in the force structure.

## 1-10. OTHER KEY FINDINGS

**a.** The current force structure process includes only a small fraction of estimated combat damage in developing force requirements.

**b.** Unit maintenance requirements, as presently calculated, are accumulated based on manhours per unit. While the original manhours may have been derived based on equipment density, at present there is no way within FASTALS to tie equipment density to manhours required.

**c.** The methodology described in this study could be used to represent other combat service support functions not presently modeled.

# CHAPTER 2

## MAINTENANCE WORKLOAD (EEA 1)

**2-1. INTRODUCTION.** This chapter describes a methodology for determining (on a microcomputer) the maintenance workload in a theater of operations using data provided by CEM and AMSAA.

**2-2. GENERAL.** The first step in developing the retrograde workload is to identify the total maintenance requirement. In the past, maintenance workloads have been poorly portrayed in many of the models and studies examined. Models usually represent reliability, availability, and maintainability (RAM) failures based on experience in the field and they neglect combat damage. Since a considerable amount of maintenance workload in wartime will be generated by combat, combat damage should have a significant impact on maintenance unit force structure as well as the retrograde workload. Future study efforts need to establish factors for combat damage for both planning and modeling purposes. For the purpose of this study, combat damage will be based on the SPARC Model, as developed by AMSAA, and selected CEM output reports produced at CAA.

**2-3. TERMINOLOGY**

**a.** Off item - term used in this study to refer to repair of components that have been removed from a piece of equipment and are repaired separately.

**b.** On item - term used in this study to refer to all repairs occurring on a piece of equipment without removal as described in 2-3a above.

c. Logical region (LR) - in order to simulate a wartime theater of operations, the FASTALS Model divides the theater into six logical regions. Of importance to this study, logical region 1 represents the division area, logical region 2 the corps, logical region 3 the rear combat zone, and logical region 4 the communications zone. For a more detailed description of the FASTALS Model, see Appendix D.

**d.** RAM failure - term used to describe maintenance failure caused only by use, not combat damage (noncombat temporary damage).

e. Typical component - term used in this study to refer to a component model that utilizes an average of repair times, weights, etc. It would be difficult to truly represent each of the hundreds of components making up today's complex technical equipment.

## 2-4. CONCEPTS EVALUATION MODEL (CEM)

a. CEM is a two-sided, theater-level, deterministic model involving land and air forces. It is designed to consider units of brigade size on the Blue side and of division size on the Red side. Command decision processes are simulated at four echelons--division, corps, army group, and theater for Blue, and corresponding echelons for Red. Simulated time is treated on a time-step basis at nested intervals of 12 hours to 4 days, depending on the echelon. Theater supply, weapon systems replacement, maintenance, repair, and hospital functions are simulated. The model calculates losses by extrapolation of shooter-target results of high-resolution combat simulations. Forward line of own troops (FLOT) movement is a function of terrain, posture, and the ratio of reduced capability for both sides.

b. Among the many reports created by CEM is the Blue Force Theaterwide Logistic Summary (Figure 2-1). This report rolls up, by category, a number of pieces of combat equipment. Using this report, total losses, RAM failures, and temporary combat damage for selected end items can be determined for the division (combat area) or logical region 1 as defined by FASTALS (see Appendix D). Due to this limitation, combat damage in the methodology will be restricted to the division (combat area). RAM failures, on the other hand, occur throughout the theater. For purposes of this methodology, these failures will be assumed to occur at the same rate in each region of the theater (uniform distribution). More sophisticated approaches based on location and battle intensity can be explored if time and resources become available. By comparing the total combat failures to the onhand figure provided in the report, a rate of combat failures per end item can be determined for the division area only. By comparing the total RAM losses to the onhand figure, a rate of failure for each region of the theater can be determined. It is imperative that the same scenario and force be used for the CEM run as provided for in the scope of the Retrograde Study.

c. Using the CEM report (Figure 2-1) and the approach described above, the rates for tank1 are determined as follows:

| | | |
|---|---|---|
| Onhand | : | 1,513.3 |
| Temp combat damage | : | 234.6 |
| RAM failures | : | 108.4 |

| | | |
|---|---|---|
| Temp combat damage/onhand | = | 15.5 percent |
| RAM failures/onhand | = | 7.2 percent |

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SCAN BASE CASE EXCUR - REVISED RED STRAT RES DIVS 04 APR 89
COMBAT UNIT SUMMARY

ALL UNITS AT END OF DIVISION CYCLE 8

(CONTINUED FROM PRECEDING PAGE)

| THEATER RESRCES | COMBAT UNIT STATUS AFTER RESUPPLY: AUTH-ORIZED | ON HAND | PER-CENT | COMBAT UNIT SUPPORT BEFORE RESUPPLY: AVAILABLE | REQUIRED | PER-CENT | TOTAL UNIT LOSSES | CUMULATIVE COMBAT UNIT LOSSES: COMBAT TEMP | COMBAT PERM | NONCOMBAT TEMP | NONCOMBAT PERM | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT/M 8 | 1812.0 | 1803.9 | 99.6 | 1341.0 | 98.1 | 999.9 | 28.6 | .0 | 363.1 | .0 | .0 | 363.1 |
| AT/M 9 | 54.0 | 54.0 | 100.0 | 1467.7 | .0 | 999.9 | .0 | .0 | 2.3 | .0 | .0 | 2.3 |
| AT/M11 | 862.0 | 853.7 | 99.0 | 466.5 | 41.3 | 999.9 | 29.5 | .0 | 371.8 | .0 | .0 | 371.8 |
| ATKSUM | 7646.0 | 6036.9 | 79.0 | 3456.0 | 1696.0 | 203.9 | 189.6 | .0 | 2528.9 | .0 | .0 | 2528.9 |
| ARTY 1 | 1467.0 | 1466.3 | 99.9 | 856.0 | 5.6 | 999.9 | 8.3 | .0 | 80.7 | .0 | .0 | 80.7 |
| ARTY 2 | 2748.0 | 2708.8 | 98.6 | 74.6 | 113.8 | 65.6 | 68.7 | .0 | 636.2 | .0 | .6 | 636.2 |
| ARTY 3 | 1300.0 | 1294.1 | 99.5 | 801.2 | 29.9 | 999.9 | 21.1 | .0 | 268.4 | .0 | .0 | 268.4 |
| ARTY 4 | 36.0 | 35.9 | 99.8 | 138.4 | .2 | 999.9 | .2 | .0 | .8 | .0 | .0 | .8 |
| ARTY 5 | 1737.0 | 1716.7 | 98.8 | 94.6 | 101.0 | 93.7 | 58.7 | .0 | 764.0 | .0 | .0 | 764.0 |
| ARTY 6 | 1966.0 | 1963.3 | 99.9 | 212.6 | 8.5 | 999.9 | 5.3 | .0 | 105.9 | .0 | .0 | 105.9 |
| ARTY 7 | 312.0 | 310.2 | 99.4 | 32.0 | 8.0 | 556.7 | 6.1 | .0 | 86.9 | .0 | .0 | 86.9 |
| ARTY 8 | 216.0 | 215.4 | 99.7 | 99.8 | 3.1 | 999.9 | 2.0 | .0 | 38.2 | .0 | .0 | 38.2 |
| ARTSUM | 9782.0 | 9711.6 | 99.3 | 2309.2 | 268.6 | 999.9 | 164.5 | .0 | 1941.2 | .0 | .0 | 1941.2 |
| ART AX | 590355.0 | 589845.6 | 99.9 | 2920483.1 | 10183.8 | 999.9 | 9497.7 | .0 | 103707.2 | .0 | .0 | 103707.2 |

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BLUE FORCE THEATERWIDE LOGISTIC SUMMARY AT END OF THEATER CYCLE 1

| THEATER RESRCES | RESOURCES ON HAND: COMBAT UNITS | THEATER STOCKS | IN REPAIR | TOTAL | LOSSES TO COMBAT UNITS: COMBAT TEMP | COMBAT PERM | NONCOMBAT TEMP | NONCOMBAT PERM | TOTAL | GAINS TO THEATER STOCKS: FROM RESUPPLY | FROM REPAIR | GAINS TO UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERSNL | 239184.9 | 1164652.8 | 4283.3 | 1408120.9 | 3069.9 | 30955.4 | 1213.4 | 811.1 | 36052.9 | 114313 | .0 | 32378.2 |
| 1 | 39824.1 | 202.9 | 739.0 | 40766.0 | 525.0 | 4857.1 | 214.0 | 143.2 | 5739.7 | 1710 | .0 | 2220.1 |
| 2 | 199360.8 | 1164449.8 | 3544.3 | 1367354.9 | 2544.9 | 26098.3 | 999.4 | 670.7 | 30313.2 | 112603 | .0 | 30158.2 |
| POL | 729726.0 | 200002092.0 | .0 | 200731818.0 | .0 | .0 | .0 | .0 | .0 | 4092 | .0 | .0 |
| 1 | 611476.0 | 100001046.0 | .0 | 100642522.0 | .0 | .0 | .0 | .0 | .5 | 2046 | .0 | .0 |
| 2 | 84250.0 | 100001046.0 | .0 | 100089296.0 | .0 | .0 | .0 | .0 | .0 | 2046 | .0 | .0 |
| AMMO | 74511.2 | 254745.0 | .0 | 329256.2 | .0 | 6494.0 | .0 | .0 | 6494.0 | 12201 | .0 | 6474.0 |
| 1 | 24880.2 | 199232.8 | .0 | 224113.0 | .0 | 2125.9 | .0 | .0 | 2125.9 | 11453 | .0 | 2116.2 |
| 2 | 49631.0 | 55512.3 | .0 | 105143.2 | .0 | 4368.1 | .0 | .0 | 4368.1 | 751 | .0 | 4357.7 |
| OTHER | 1690244.0 | 200002092.0 | .0 | 201692336.0 | .0 | .0 | .0 | .0 | .0 | 4092 | .0 | .0 |
| 1 | 1010332.0 | 100001046.0 | .0 | 101011378.0 | .0 | .0 | .0 | .0 | .0 | 2046 | .0 | .0 |
| 2 | 679912.0 | 100001046.0 | .0 | 100680958.0 | .0 | .0 | .0 | .0 | .0 | 2046 | .0 | .0 |
| TNKS 1 | 1513.3 | 246.1 | 343.1 | 2102.5 | 234.6 | 88.5 | 108.4 | 6.1 | 397.6 | 55 | .0 | 388.9 |
| TNKS 4 | 2265.5 | .0 | 744.1 | 3009.6 | 566.5 | 186.2 | 177.7 | 12.2 | 941.5 | 8 | .0 | 938.0 |
| TNKS 5 | 3414.5 | 26.5 | 787.7 | 4228.7 | 569.5 | 739.7 | 218.2 | 15.5 | 1543.0 | 5 | .0 | 1991.5 |
| TNKS 7 | 46.2 | .0 | 41.6 | 87.8 | 37.8 | 9.9 | 5.8 | .2 | 51.7 | 3 | .0 | .0 |
| TNKS 6 | 115.2 | .0 | 9.0 | 124.2 | .6 | 1.3 | 8.4 | .5 | 10.8 | 3 | .0 | .0 |
| TNKSUM | 7354.9 | 272.6 | 1925.5 | 9552.9 | 1439.0 | 985.6 | 516.5 | 33.8 | 2944.5 | 69. | .0 | 2798.4 |
| APCS 1 | 733.2 | .0 | 446.6 | 1179.8 | 430.4 | 66.7 | 46.2 | 2.5 | 515.8 | 105 | .0 | 277.0 |
| APCS 2 | 299.2 | .0 | 152.8 | 452.0 | 134.7 | 21.9 | 18.1 | 2.1 | 176.8 | 13 | .0 | 97.0 |
| APCS 3 | 214.5 | 1273.2 | 61.0 | 1548.8 | 59.8 | 25.5 | 1.2 | 11.7 | 98.3 | 16 | .0 | 96.8 |
| APCS 4 | 106.8 | 107.2 | 22.6 | 236.5 | 18.0 | 35.9 | 4.6 | .5 | 59.0 | 5 | .0 | 57.8 |
| APCS 5 | 184.3 | .0 | 35.6 | 219.9 | 24.2 | 3.5 | 11.4 | .6 | 39.7 | 3 | .0 | 20.0 |
| APCS 6 | 190.7 | 142.3 | 59.7 | 392.8 | 49.2 | 7.0 | 10.5 | 1.2 | 67.9 | 3 | .0 | 66.7 |
| APCS 7 | 858.7 | 1117.5 | 249.0 | 2825.1 | 202.8 | 21.6 | 46.2 | 5.5 | 275.9 | 135 | .0 | 268.5 |
| APCS 8 | 1059.3 | .0 | 665.3 | 1724.6 | 596.2 | 463.0 | 69.1 | 9.3 | 1136.7 | 3 | .0 | .0 |
| APCS 9 | 4236.8 | .0 | 1559.9 | 5796.7 | 1276.1 | 377.2 | 283.8 | 17.1 | 1954.2 | 13 | .0 | 272.0 |
| APCS10 | 515.0 | .0 | 23.0 | 538.0 | 2.4 | 4.1 | 23.5 | 2.8 | 30.9 | 3 | .0 | .0 |
| APCS11 | 5397.5 | .0 | 1911.8 | 7309.3 | 1629.7 | 1167.8 | 282.1 | 36.3 | 3116.5 | 35 | .0 | 2677.0 |
| APCS12 | 6495.1 | .0 | 2629.5 | 9124.5 | 2272.1 | 437.9 | 357.8 | 47.5 | 3114.9 | 45 | .0 | 2414.0 |
| APCSUM | 20291.2 | 3240.1 | 7816.6 | 31348.0 | 6665.6 | 2632.3 | 1151.1 | 136.5 | 13585.6 | 363. | .0 | 6246.9 |

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Figure 2-1. CEM Blue Force Theaterwide Logistic Summary

**d.** Once these factors have been derived, it is an easy matter to determine end item failures based on equipment density for each region of the theater. Note that data in Figure 2-1 is not provided in integer values. Table 2-1 illustrates how such a breakdown might appear.

Table 2-1. Sample Tank Data

| | COMMZ | COSCOM | Corps | Division |
|---|---|---|---|---|
| Onhand | 200 | 300 | 500 | 1,200 |
| Temp cbt damage | 0 | 0 | 0 | 186 |
| RAM failure | 14 | 21 | 36 | 86 |
| Total damaged | 14 | 21 | 36 | 272 |

## 2-5. THE US ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY (AMSAA)

**a.** As part of its mission, AMSAA has established a number of maintenance related data bases. Data on combat damage is available for that equipment evaluated by the SPARC Model. RAM data are available based on field experience.

**b.** AMSAA is capable of providing combat and RAM failure data for selected maintenance systems as follows:

**(1)** Repair and damage distributions by level of maintenance (organizational, direct support, and general support).

**(2)** Repair and damage distributions by type maintenance (automotive, firepower, and missile).

**(3)** Establish a typical component requiring repair on a system (end item).

**(4)** The relationship between damaged end items and "typical" components.

**(5)** The distribution of maintenance actions occurring "off item."

**(6)** The average time required for maintenance actions "on item" and "off item."

**c.** For purposes of developing this model, AMSAA provided sample data (Appendix E) which will be used throughout this and subsequent chapters.

**2-6. DETERMINATION OF MAINTENANCE WORKLOAD.** Using CEM output reports such as Figure 2-1 and data provided by AMSAA, it is possible to determine an estimated maintenance workload for each theater region over time. The best way to explain the method is by use of example. For the purpose of this example, the division-level data appearing in Table 2-2 for tanks will be utilized.

**Table 2-2. M1 Tank Data**

| Type damage | Tanks |
|---|---|
| Temporary combat | 186 |
| RAM | 86 |

**a.** The first task is to distribute the damaged tanks by echelon of maintenance and category of maintenance. For example, using the M1 tank data from Table 2-2 and App E (page E-5), 28 percent of the 186 combat-damaged tanks is distributed at organizational maintenance level. Of the 52 items, 44 percent are for automotive repair, 56 percent for firepower repair, and 0 percent for missile repair. This process is repeated for the remaining combat damage and RAM failure echelon distributions. Table 2-3 shows how many end items are located in each category. These end items (systems) represent maintenance actions that will be conducted "on item." Actions taking place "on item" consist of repair or replacement of damaged components. At the organizational level, emphasis is on the replacement of damaged components.

**Table 2-3. Calculation of Damaged End Items (at division level)**

| Combat damage | | Automotive | Firepower | Missile | Total |
|---|---|---|---|---|---|
| Echelon distribution | | 44% | 56% | 0% | |
| Org | 28% | 23 | 29 | 0 | 52 |
| DS | 67% | 55 | 70 | 0 | 125 |
| GS | 5% | 4 | 5 | 0 | 9 |
| Total | | 82 | 104 | 0 | 186 |
| **RAM failures** | | **Automotive** | **Firepower** | **Missile** | **Total** |
| Echelon distribution | | 25.8% | 74.2% | 0.0% | |
| Org | 86.1% | 19 | 55 | 0 | 74 |
| DS | 12.1% | 3 | 8 | 0 | 10[a] |
| GS | 1.8% | 0 | 1 | 0 | 2[a] |
| Total | | 22 | 64 | 0 | 86 |

[a]Totals vary due to rounding.

b. Maintenance actions occurring "on item" create "off item" maintenance actions (Table 2-4). For example, a damaged transmission has been extracted from an end item. This constitutes an "on item" action. As a result of this action, however, a requirement has been created for the repair of the damaged transmission, an "off item" action. Not all "on item" work creates "off item" action workloads. As described, some of the actions are completed (e.g., a component is replaced). Components beyond repair may be abandoned as total losses. To account for this, AMSAA has provided the factor of .878 which, when multiplied by the total of temporary combat damaged/RAM failures, gives the total number of "off item" actions to be expected (186 combat damaged end items x .878 = 163 "off item" actions). "Off item" actions are primarily concerned with the repair of damaged components. Few, if any, repairs of components are conducted at the organizational level; therefore, the work is distributed between DS and GS maintenance with the majority (95.8 percent) of the work at the DS level. "Off item" actions are distributed by category in the same manner as the "on item" actions.

Table 2-4. Distribution of "Off Item" Actions

| Combat damage | | Factor = 0.878 | | | |
|---|---|---|---|---|---|
| | | Automotive | Firepower | Missile | Total |
| Echelon distribution | | 8.1% | 91.9% | 0.0% | |
| DS | 95.8% | 13 | 144 | 0 | 157 |
| GS | 4.2% | 0 | 6 | 0 | 6 |
| Total | | 13[a] | 150 | 0 | 163[a] |
| **RAM failures** | | Automotive | Firepower | Missile | Total |
| Echelon distribution | | 8.1% | 91.9% | 0.0% | |
| DS | 95.8% | 6 | 66 | 0 | 72 |
| GS | 4.2% | 1 | 3 | 0 | 4[a] |
| Total | | 7 | 69 | 0 | 76 |

[a]Totals vary due to rounding

c. A maintenance workload in terms of "on item" and "off item" actions has now been generated for each echelon and category of maintenance for the tank. Similar workloads can be created for other systems for each region of the theater of operations.

d. If a maintenance shortfall and therefore an evacuation/retrograde requirement is to be determined, the maintenance workload must be compared to maintenance capability. To perform this comparison, it is necessary to convert the maintenance workload into maintenance manhours. In Appendix E, the mean manhours required for "on item" and "off item" actions have been provided (AMSAA data). Multiplying the workloads in Tables 2-3 and 2-4 by

the mean manhours in Appendix E produces the required workload in manhours, as shown in Tables 2-5 and 2-6.

Table 2-5. Manhours Required "On Item" Actions

**Mean manhours**

| Temp combat damage | Automotive | Firepower (from Appendix E-5) | Missile |
|---|---|---|---|
| Echelon | | | |
| Org | 9.44 | 10.28 | 0.00 |
| DS | 23.93 | 36.76 | 0.00 |
| GS | 43.84 | 74.66 | 0.00 |

**Workload in manhours**

| Temp combat damage | Automotive | Firepower | Missile | Total |
|---|---|---|---|---|
| Echelon | | | | |
| Org | 23 x 9.44 = 217 | 29 x 10.28 = 298 | 0 | 515 |
| DS | 55 x 23.93 = 1316 | 70 x 36.76 = 2573 | 0 | 3889 |
| GS | 4 x 43.84 = 175 | 5 x 74.66 = 373 | 0 | 548 |
| Total | 1708 | 3244 | 0 | 4952 |

**Mean manhours**

| RAM failure | Automotive | Firepower (from Appendix E-3) | Missile |
|---|---|---|---|
| Echelon | | | |
| Org | 4.1 | 9.8 | 0.0 |
| DS | 5.1 | 10.4 | 0.0 |
| GS | 1.7 | 1.6 | 0.0 |

**Workload in manhours**

| RAM failure | Automotive | Firepower | Missile | Total |
|---|---|---|---|---|
| Echelon | | | | |
| Org | 19 x 4.1 = 78 | 55 x 9.8 = 539 | 0 | 617 |
| DS | 3 x 5.1 = 15 | 8 x 10.4 = 83 | 0 | 98 |
| GS | 0 x 1.7 = 0 | 1 x 1.6 = 2 | 0 | 2 |
| Total | 93 | 624 | 0 | 717 |

Table 2-6. Manhours Required "Off Item" Actions

| | | Mean manhours | | |
|---|---|---|---|---|
| Temp combat damage | Automotive | Firepower (from Appendix E-5) | Missile | |
| Echelon | | | | |
| DS | 23.93 | 36.76 | 0.00 | |
| GS | 43.84 | 74.66 | 0.00 | |
| | | **Workload in manhours** | | |
| | Automotive | Firepower | Missile | Total |
| Echelon | | | | |
| DS | 13 x 23.93 = 311 | 144 x 36.76 = 5293 | 0 | 5604 |
| GS | 1 x 43.84 = 44 | 6 x 74.66 = 448 | 0 | 492 |
| Total | 355 | 5741 | 0 | 6096 |
| | | **Mean manhours** | | |
| RAM failure | Automotive | Firepower (from Appendix E-3) | Missile | |
| Echelon | | | | |
| DS | 3.90 | 2.00 | 0.00 | |
| GS | 19.10 | 3.50 | 0.00 | |
| | | **Workload in manhours** | | |
| | Automotive | Firepower | Missile | Total |
| Echelon | | | | |
| DS | 6 x 3.90 = 23 | 66 x 2.0 = 132 | 0 | 155 |
| GS | 0 x 19.10 = 0 | 3 x 3.5 = 11 | 0 | 11 |
| Total | 23 | 143 | 0 | 166 |

e. Table 2-7 summarizes the tank maintenance workload, by category, in manhours within the division area. To determine total maintenance workload, such a table would be created for each region of the theater of operations, for each end item studied.

Table 2-7. Summary of Tank Maintenance Workload (required manhours)

| | DS | GS | Total |
|---|---|---|---|
| Automotive | | | |
| End items - Temp CBT | 1316 | 175 | 1491 |
| End items - RAM | 15 | 2 | 17 |
| Components - Temp CBT | 311 | 44 | 355 |
| Components - RAM | 23 | 0 | 23 |
| Total | 1665 | 221 | 1886 |
| Firepower | | | |
| End items - Temp CBT | 2573 | 373 | 2946 |
| End items - RAM | 83 | 2 | 85 |
| Components - Temp CBT | 5293 | 448 | 5741 |
| Components - RAM | 132 | 11 | 143 |
| Total | 8081 | 834 | 8915 |
| Missile | | | |
| End items - Temp CBT | 0 | 0 | 0 |
| End items - RAM | 0 | 0 | 0 |
| Components - Temp CBT | 0 | 0 | 0 |
| Components - RAM | 0 | 0 | 0 |
| Total | 0 | 0 | 0 |

2-7. **SUMMARY.** This chapter has presented a methodology for determining maintenance workload by area over time within a theater of operations. The method is dependent on data from a combat simulation model such as CEM and that provided by AMSAA. As mentioned in Chapter 1, AMSAA data is only available for items evaluated by the SPARC process. The SPARC methodology continues to be utilized and can be expected to produce additional combat planning data in the future.

# CHAPTER 3

## MAINTENANCE CAPABILITY (EEA 2)

**3-1. INTRODUCTION.** This chapter describes a methodology for determining the maintenance capability in a theater of operations using the Program Objective Memorandum (POM) force. The methodology used here is derived from that used for the ESTIMATE-86 Study.

**3-2. GENERAL**

**a.** The intermediate support maintenance level is organized as DS and GS. Direct support is characterized by highly mobile forward orientation and repair of equipment by replacement of unserviceable modules. By contrast, GS maintenance will typically operate from semifixed facilities in which commodity-oriented platoons will repair equipment and components in support of the theater supply system.

**b.** According to doctrine, maintenance not capable of being performed at lower echelons may be passed rearward to higher echelons of maintenance. This passing back of maintenance requirements creates the evacuation/retrograde workload within the transportation system.

**3-3. MAINTENANCE UNITS.** There are many types of maintenance units in the Army. Those active maintenance units having a DS or GS mission during the timeframe of interest should be identified. From these units, the total maintenance capability in manhours by area can be determined. Typical maintenance units in the current structure are displayed in Table 3-1. Maintenance teams should be included in determining maintenance capability.

Table 3-1. Selected Maintenance Units

| Unit | Standard requirement code (SRC) |
|---|---|
| Light Maintenance Company | 29-016H00010 |
| Heavy Maintenance Company | 43-008J40027 |
| Forward Support Company | 29-017H00010 |

**3-4. POM FORCE**

**a.** Maintenance unit requirements are shown on the POM force tape by component (COMPO). Each unit requirement is annotated by one of seven COMPO designators. The COMPO designator indicates whether the requirement will be met with US Army forces (active or reserve) or offset by host nation support (HNS) in the form of either similar military units (direct HNS), equivalent support from the host nation civilian sector (indirect HNS) or offset with civilian contractor support provided on the basis of contingency contract through the logistical civil augmentation program (LOGCAP). Any requirement

which cannot be met through one of the several means described above is defined as a shortfall or "unmanned" requirement. Table 3-2 shows the COMPO designators in the POM force file. COMPOs 1, 2, 3, 7, 8, and 9 represent the manned force and therefore the maintenance capability present for the time period in question.

**Table 3-2. Force Structure Component (COMPO) Designators**

| COMPO | Type organization |
|---|---|
| 1 | Active Army |
| 2 | National Guard |
| 3 | Army Reserve |
| 4 | Unmanned requirement |
| 5 | Not used |
| 6 | Not used |
| 7 | Direct host nation support |
| 8 | Indirect host nation support |
| 9 | Contingency contract (LOGCAP) |

b. To identify which units are manned, the SRCs of the units of interest (see paragraph 3-3 above) need to be matched to the POM using the Army Master Force (M-Force) tape provided by the Force Accounting System (FAS). Once these units have been extracted by SRC, a sort of the file can be made using the CAA unit data system (UDS) to identify those units which are manned in the force using the above criteria.

## 3-5. TOE CAPABILITY ANALYSIS

a. Four data sources are required to compute unit capabilities: TOEs from the US Army Management System Support Agency (USAMSSA) TOE tapes, current available productive manhour factors from the Manpower Requirements Criteria (MARC) in Army Regulation (AR) 570-2, input from TOE proponents, and the listing of maintenance units identified as explained in paragraph 3-3 above. Table 3-3 shows MARC factors that can be used in determining maintenance capability. These daily factors are computed by dividing the annual productive manhours keyed to theater location by 365 days.

Table 3-3. Manhours per Man per Day

| Type unit | Unit location | | |
|---|---|---|---|
| | Division | Corps | COMMZ |
| Nondivisional maint company | 6.4 | 7.6 | 8.5 |
| Light equipment maint company | 6.4 | 7.6 | 8.5 |
| Heavy equipment maint company | 6.4 | 7.6 | 8.5 |
| Aircraft maintenance company | 6.4 | 7.6 | 8.5 |
| Ord company, guided missile | 6.4 | 7.6 | 8.5 |

b. Using the SRCs and the USAMSSA TOE tapes, a file of TOE positions by SRC code can be generated. Hard copy worksheets allow for a review of unit positions with the TOE proponent centers in the US Army Training and Doctrine Command (TRADOC). As a result, primary mission personnel by position can be identified for determining daily maintenance capability. These personnel can then be quantified by MOS and category of maintenance (automotive, firepower, missile).

c. To compute the capability of each unit, the planning factors given in Table 3-3 can be utilized to determine the unit capability in manhours. To determine maintenance capability, the number of personnel by MOS and category in each unit are multiplied by the appropriate factor as provided in Table 3-3. The overall maintenance capability is obtained by multiplying the result of this calculation by the total number of units of that type available in each region by time period. The capability of the different units is then added together.

## 3-6. SAMPLE CALCULATIONS

a. By examining the force, the intermediate maintenance units are identified. For this example, the Heavy Maintenance Company, SRC43-008J40027, will be utilized.

b. Next, using the TOE data, the mission proponent positions for each TOE are selected. These MOSs are then separated into maintenance categories to simplify the model. Table 3-4 is a table of selected MOSs by category. Only those MOSs which directly perform the maintenance mission should be considered. Supervisory and organization support personnel are excluded.

Table 3-4. Mission Proponent MOS by Category

| Automotive | Firepower | Missile |
|---|---|---|
| 63B | 41C | 24G |
| 63D | 45D | 24M |
| 63W | 45K | 24N |

c. The heavy maintenance company is authorized seven MOS 63B at level 1. In the division area, each soldier can perform 6.4 hours of productive work per day (Table 3-3). Therefore, for each heavy maintenance company, 44.8 hours of automotive capability are generated. Similar calculations are made for each MOS until total automotive, firepower, and missile capabilities for the division, corps, and communications zone (COMMZ) are computed. The result should be a table similar to Table 3-5.

Table 3-5. Heavy Maintenance Company Capability (manhours/day)

| Category | Unit location | | |
|---|---|---|---|
| | Division | Corps | COMMZ |
| Automotive | 562 | 667 | 746 |
| Firepower | 67 | 80 | 89 |
| Missile | 0 | 0 | 0 |

d. The number of manned heavy maintenance units by area over time is extracted from the POM force. Suppose the extraction yields 10 units in each of three areas appearing in Table 3-5. Then the total maintenance capability in the categories examined for the heavy maintenance company is provided in Table 3-6. Similar calculations can be made for each maintenance unit or team, and the results are then totaled. Using this method, the total maintenance capability can be determined by area over time in each of the three categories described.

Table 3-6. Total Capability of Heavy Maintenance Units (manhours)

| Category | Unit location | | |
|---|---|---|---|
| | Division | Corps | COMMZ |
| Automotive | 5,620 | 6,670 | 7,460 |
| Firepower | 670 | 800 | 890 |
| Missile | 0 | 0 | 0 |

3-7. **SUMMARY.** This chapter has presented a methodology for determining maintenance capability by location in the theater of operations over time. The methodology is derived from the methodology utilized in the ESTIMATE-86 and other studies. The current methodology is limited to the three categories of maintenance (automotive, firepower, missile). Expanding the scope of the study to include more categories can significantly improve the realism of the model.

# CHAPTER 4

## MAINTENANCE SHORTFALLS (EEA 3)

**4-1. INTRODUCTION.** This chapter describes a methodology for determining the maintenance shortfall in a theater of operations by comparing the maintenance workload (Chapter 2) to the maintenance capability (Chapter 3). Materiel that cannot be repaired due to lack of capability is evacuated immediately to the next higher level maintenance facility.

**4-2. PRIORITY**

**a.** A methodology for determining the maintenance workload within a theater of operations is described in Chapter 2. Maintenance capability in a theater is limited; therefore, the first task in modeling the repair process is to assign a priority to the materiel to be repaired. Maintenance doctrine provides some guidance in assigning priority. For example, end items will normally be repaired before components; jobs of shorter duration will be done before longer jobs. The objective is to return the maximum number of end items to service in the minimum time. Combat damage is more likely to result in longer repair times than RAM failures and therefore would be repaired after RAM failures have been repaired and returned to service. Considering the above factor for each end item, a typical repair priority sequence is shown in Table 4-1.

**Table 4-1. Priority Scheme for End Item Repair**

| Priority | Category |
|---|---|
| 1 | RAM failures - end item |
| 2 | Temp combat damage - end item |
| 3 | RAM failures - end item - component |
| 4 | Temp combat damage - end item - component |

**b.** Maintenance doctrine cannot provide guidance on priorities among different end items. The decision on whether a tank or an armored personnel carrier should be repaired first is a command prerogative and is situation-dependent. For purposes of analysis, a priority scheme must be established by the analyst. In the simplified example of paragraph 4-5, the priority scheme of Table 4-2 will be utilized.

Table 4-2. Typical Equipment Priorities

| Priority | End item |
|---|---|
| 1 | M1 Tank |
| 2 | M2 Bradley |
| 3 | M109 Howitzer |

c. As mentioned in paragraph 4-2a, end items have priority over components. Therefore, an M2 Bradley end item should be repaired before an M1 component. The resulting overall priority scheme for the 12 different categories is now summarized in Table 4-3.

Table 4-3. Overall Priority (illustrated)

| Priority | End item |
|---|---|
| 1 | RAM failure - M1 tank |
| 2 | Temp combat damage - M1 tank |
| 3 | RAM failure - M2 Bradley |
| 4 | Temp combat damage - M2 Bradley |
| 5 | RAM failure - M109 howitzer |
| 6 | Temp combat damage - M109 howitzer |
| 7 | RAM failure - M1 tank - component |
| 8 | Temp combat damage - M1 tank - component |
| 9 | RAM failure - M2 Bradley - component |
| 10 | Temp combat damage - M2 Bradley - component |
| 11 | RAM failure - M109 howitzer - component |
| 12 | Temp combat damage - M109 howitzer - component |

d. There is one final priority consideration. Direct support maintenance work which cannot be repaired at DS level can be passed back to general support level. By doctrine, GS units should do DS work before doing GS work (DS work should require less time). In the same manner, DS work may be passed rearward to a depot facility. Table 4-4 shows this priority relationship. Thus, for just three end items, 36 priorities can be established.

Table 4-4. Level of Maintenance Priority

| Priority | End item |
|---|---|
| 1 | Direct support maintenance |
| 2 | General support maintenance |
| 3 | Depot maintenance |

**4-3. MAINTENANCE LEVELS.** In a simplified theater model, there are three levels of maintenance repair: direct support, direct support/general support, and general support. The term direct support/general support refers to that DS maintenance which will be performed at the GS level. At present, GS units are only located in the COMMZ.

**4-4. REPAIR**

a. Damaged components will be repaired according to the priorities described in paragraph 4-2. All GS work will be evacuated to the COMMZ for repair. The FASTALS Model describes each area of the theater as a logical region (LR) as shown in Table 4-5. For the purpose of this study, the same descriptions will be used. Each logical region will have one location where all maintenance capability is accumulated for that region.

Table 4-5. FASTALS Logical Regions

| Logical region | Area |
|---|---|
| LR1 | Division |
| LR2 | Corps |
| LR3 | Rear combat zone (corps support command (COSCOM)) |
| LR4 | COMMZ |
| LR5 | Ports |

b. For each time period, each logical region will generate a maintenance workload based on the density of equipment in that region (Chapter 2) and a maintenance capability based on the density of maintenance units in the region (Chapter 3). Workloads and capability will be collocated at one location as described in paragraph 4-4a above. Workloads will be prioritized as described in paragraph 4-2 and compared to maintenance capability. Those workloads by priority that are less than the maintenance capability will be considered repaired. Those workloads in priority that exceed maintenance capability constitute a shortfall to be evacuated to the next logical region.

This shortfall is added to the workload already present in the higher logical region. The same comparison and shortfall creation process continues until all requirements are either satisfied or accumulated in logical region 5.

**4-5. EXAMPLE.** The best way to describe the methodology which can be carried out within a computerized spreadsheet is by illustration. Tables 4-6 and 4-7 provide a simulated automotive workload and maintenance capability, respectively, for use in this description.

**Table 4-6. Automotive Maintenance Workload (manhours)**

| Logical region | | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | DS | GS | DS | GS | DS | GS | DS | GS |
| M1/RAM | (M1/R)[a] | 100 | 20 | 100 | 20 | 100 | 20 | 100 | 20 |
| M1/Combat | (M1/C)[a] | 1,300 | 170 | 0 | 0 | 0 | 0 | 0 | 0 |
| M2/RAM | (M2/R) | 200 | 20 | 200 | 20 | 200 | 20 | 200 | 20 |
| M2/Combat | (M2/C) | 500 | 90 | 0 | 0 | 0 | 0 | 0 | 0 |
| M1/RAM component | (M1/RC)[a] | 80 | 16 | 80 | 16 | 80 | 16 | 80 | 16 |
| M1/Combat component | (M1/CC)[a] | 1,040 | 136 | 0 | 0 | 0 | 0 | 0 | 0 |
| M2/RAM component | (M2/RC) | 160 | 16 | 160 | 16 | 160 | 16 | 160 | 16 |
| M2/Combat component | (M2/CC) | 400 | 72 | 0 | 0 | 0 | 0 | 0 | 0 |

[a]Abbreviations used in this and the following spreadsheets: R = RAM failure end items, C = combat damaged end items, RC = RAM failure components, CC = combat damaged components.

**Table 4-7. Automotive Maintenance Capability (manhours)**

| Logical region | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Echelon | | | | |
| DS | 2,800 | 500 | 500 | 500 |
| GS | 0 | 0 | 0 | 900 |

a. Table 4-8 shows how the shortfall is determined in the first logical region. Each of the types of work to be done is listed by priority vertically on the table. M1s will be repaired before M2s, and DS work is done first. The DS capacity (DS CAP) of 2,800 hours is compared to the M1 RAM failure (M1/R) requirement in hours. As there is more than enough capability, the 100 hours of repair work are completed. The capacity drops to 2,700 hours and is compared to the requirement of the M1 combat damaged requirement (M1/C) of 1,300 hours. This requirement is satisfied as well. The process continues until all of the DS capability is consumed. As a result, only part of the 1,040-hour requirement to repair M1 components damaged in combat (M1/CC) can be satisfied. No M2 damaged components are repaired. These requirements could be satisfied by GS units in a backup role, but since there are no GS units in logical region 1, the remaining DS requirements are all shortfalls. For the same reason, none of the GS requirements are satisfied.

Table 4-8. Shortfall Determination - Logical Region 1

| Maint level | DS (hrs) | | | DS/GS (hrs) | | | GS (hrs) | | | Shortfall | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Job | CAP | Rqmt | Done | CAP | Rqmt | Done | CAP | Rqmt | Done | DS | GS |
| M1/R | 2,800 | 100 | -100 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 20 |
| M1/C | 2,700 | 1,300 | -1,300 | 0 | 0 | 0 | 0 | 170 | 0 | 0 | 170 |
| M2/R | 1,400 | 200 | -200 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 20 |
| M2/C | 1,200 | 500 | -500 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 90 |
| M1/RC | 700 | 80 | -80 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 16 |
| M1/CC | 620 | 1,040 | -620 | 0 | 420 | 0 | 0 | 136 | 0 | 420 | 136 |
| M2/RC | 0 | 160 | 0 | 0 | 160 | 0 | 0 | 16 | 0 | 160 | 16 |
| M2/CC | 0 | 400 | 0 | 0 | 400 | 0 | 0 | 72 | 0 | 400 | 72 |

b. Logical region 2 is shown in Table 4-9. Note again that combat damaged is not represented to the rear of the division area, a limitation of CEM. The process for determining the shortfall is the same as for logical region 1 with one difference. The shortfall from logical region 1 has been added to the requirements of logical region 2. Logical region 2 now has a DS maintenance requirement for 420 hours of combat damaged components for the M1. This represents the 420 hours of shortfall evacuated from logical region 1. This is critical in that this methodology is concerned with developing transportation requirements within the theater. The assumption that adequate capability exists to transport damaged materiel from logical region 1 to logical region 2 is essential in determining the transportation requirements within logical region 2.

Table 4-9. Shortfall Determination - Logical Region 2

| Maint level | DS (hrs) | | | DS/GS (hrs) | | | GS (hrs) | | | Shortfall | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Job | CAP | Rqmt | Done | CAP | Rqmt | Done | CAP | Rqmt | Done | DS | GS |
| M1/R | 500 | 100 | -100 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 40 |
| M1/C | 400 | 0 | 0 | 0 | 0 | 0 | 0 | 170 | 0 | 0 | 170 |
| M2/R | 400 | 200 | -200 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 40 |
| M2/C | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 90 |
| M1/RC | 200 | 80 | -80 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 32 |
| M1/CC | 120 | 420 | -120 | 0 | 300 | 0 | 0 | 136 | 0 | 300 | 136 |
| M2/RC | 0 | 320 | 0 | 0 | 320 | 0 | 0 | 32 | 0 | 320 | 32 |
| M2/CC | 0 | 400 | 0 | 0 | 400 | 0 | 0 | 72 | 0 | 400 | 72 |

c. The same process continues for logical region 3 as shown in Table 4-10. There are no new combat requirements. GS capability (GS CAP) is not present. Shortfalls from logical region 2 have been added to the workload requirements for logical region 3.

Table 4-10. Shortfall Determination - Logical Region 3

| Maint level | DS (hrs) | | | DS/GS (hrs) | | | GS (hrs) | | | Shortfall | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Job | CAP | Rqmt | Done | CAP | Rqmt | Done | CAP | Rqmt | Done | DS | GS |
| M1/R | 500 | 100 | -100 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 60 |
| M1/C | 400 | 0 | 0 | 0 | 0 | 0 | 0 | 170 | 0 | 0 | 170 |
| M2/R | 400 | 200 | -200 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 60 |
| M2/C | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 90 |
| M1/RC | 200 | 80 | -80 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 48 |
| M1/CC | 120 | 300 | -120 | 0 | 180 | 0 | 0 | 136 | 0 | 180 | 136 |
| M2/RC | 0 | 480 | 0 | 0 | 480 | 0 | 0 | 48 | 0 | 480 | 48 |
| M2/CC | 0 | 400 | 0 | 0 | 400 | 0 | 0 | 72 | 0 | 400 | 72 |

d. In logical region 4, Table 4-11, GS maintenance capability exists. The new capability changes the process slightly. Look at the DS requirement for M1 components damaged by combat (M1/CC). The requirement is for 180 hours of repair. The capability to repair only 120 hours results in a shortfall of 60 hours. In logical region 4, GS capability does exist and, by doctrine, provides backup support to DS. Therefore, GS capability is used to repair the 60 hours of unsatisfied DS requirements before working on GS requirements. The process continues as before, resulting in a greatly reduced shortfall in logical region 4. In this example, all requirements have been satisfied with the exception of damaged M2 components.

Table 4-11. Shortfall Determination - Logical Region 4

| Maint level / Job | DS (hrs) | | | DS/GS (hrs) | | | GS (hrs) | | | Shortfall | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | CAP | Rqmt | Done | CAP | Rqmt | Done | CAP | Rqmt | Done | DS | GS |
| M1/R | 500 | 100 | -100 | 900 | 0 | 0 | 900 | 80 | -80 | 0 | 0 |
| M1/C | 400 | 0 | 0 | 820 | 0 | 0 | 820 | 170 | -170 | 0 | 0 |
| M2/R | 400 | 200 | -200 | 650 | 0 | 0 | 650 | 80 | -80 | 0 | 0 |
| M2/C | 200 | 0 | 0 | 570 | 0 | 0 | 570 | 90 | -90 | 0 | 0 |
| M1/RC | 200 | 80 | -80 | 480 | 0 | 0 | 480 | 64 | -64 | 0 | 0 |
| M1/CC | 120 | 180 | -120 | 416 | 60 | -60 | 356 | 136 | -136 | 0 | 0 |
| M2/RC | 0 | 640 | 0 | 220 | 640 | -220 | 0 | 64 | 0 | 420 | 64 |
| M2/CC | 0 | 400 | 0 | 0 | 400 | 0 | 0 | 72 | 0 | 400 | 72 |

e. Table 4-12 summarizes the automotive maintenance shortfalls that exist in each logical region. These shortfalls represent materiel that must be transported between each of the logical regions and therefore are transportation requirements. In their current form, these requirements are in manhours of materiel to be moved. Chapter 5 describes the methodology for converting this shortfall into meaningful transportation workloads.

Table 4-12. Summary of Shortfall (maintenance manhours)

| Region | M1/R | M1/C | M2/R | M2/C | M1/RC | M1/CC | M2/RC | M2/CC |
|---|---|---|---|---|---|---|---|---|
| LR1 | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 420 | 160 | 400 |
| GS | 20 | 170 | 20 | 90 | 16 | 136 | 16 | 72 |
| LR2 | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 300 | 320 | 400 |
| GS | 40 | 170 | 40 | 90 | 32 | 416 | 32 | 72 |
| LR3 | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 180 | 480 | 400 |
| GS | 60 | 170 | 60 | 90 | 48 | 136 | 48 | 72 |
| LR4 | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 0 | 420 | 400 |
| GS | 0 | 0 | 0 | 0 | 0 | 0 | 64 | 72 |

4-6. SUMMARY. This chapter has presented a methodology for determining maintenance shortfall by area over time within a theater of operations. Priority of repair is an essential element of the process. Adjusting priorities would be an excellent candidate for sensitivity analysis.

# CHAPTER 5

## TRANSPORTATION WORKLOAD (EEA 4)

**5-1. INTRODUCTION.** This chapter describes a methodology for converting maintenance shortfall in a theater of operations into movement workloads for the transportation system.

**5-2. TERMINOLOGY**

**a.** LR - in order to simulate a wartime theater of operations, the FASTALS Model divides the theater into six logical regions. Logical region 1 represents the division area, logical region 2 the corps, logical region 3 the rear combat zone, and logical region 4 the communications zone. For a more detailed description of the FASTALS Model, see Appendix D.

**b.** RAM failure - term used to describe maintenance failure caused by using the equipment.

**c.** DS maintenance - maintenance normally authorized and performed by designated maintenance activities in direct support of using organizations. This category of maintenance is limited to the repair of end items or unserviceable assemblies in support of using organizations on a return-to-user basis.

**d.** GS maintenance - maintenance authorized and performed in support of the Army supply system. Normally, equipment is repaired to required maintenance standards in a ready-to-issue condition.

**5-3. TRANSPORTATION WORKLOADS**

**a.** Workloads in transportation can be specified as either items to be moved or short tons (STON) to be moved. HETs are used to move outsized, heavy items within the theater. Those end items which require a HET for movement should be identified prior to inclusion in the model. The majority of repairs in the forward areas will be made up of component exchange. This policy and the policy of repairing end items prior to components will help ensure that the majority of materiel moving rearward will be damaged components. Damaged components are usually transported as general cargo using short tons as the unit of measure. Medium truck companies are associated with the movement of short tons. Some end items, a jeep, for example, do not require a large vehicle such as a HET and fit quite easily on a flatbed trailer. Such end items should be identified prior to implementation of this methodology. Before movement, these end items will be converted to short tons for transport by medium truck units. Table 5-1 describes the potential transportation workloads.

Table 5-1. Transportation Workloads

| Workload | Unit of measure | Mode of transport |
|---|---|---|
| Heavy, large end items | Each | HET |
| Small, lightweight end items | Short tons | Medium truck |
| Damaged components | Short tons | Medium truck |

b. It is possible for damaged materiel to be transported by rail from the corps to the rear of the theater of operations. Rail capacity, when present in a theater, should easily exceed any requirements for movement of damaged materiel. The presence of rail, however, cannot be expected to reduce the transportation workload for military highway. In some cases, it will increase the highway workload. Maintenance control points are not necessarily located at a railhead. Therefore, military trucks will have to take damaged equipment to the railhead for loading and from the railhead once offloaded. The journey from the railhead constitutes an additional transportation workload for military highway units.

c. In Chapter 4, a workload to be transported was identified in maintenance manhours, as shown in Table 5-2.

Table 5-2. Summary of Shortfall (maintenance manhours)

| LR | M1/R[a] | M1/C[a] | M2/R | M2/C | M1/RC[a] | M1/CC[a] | M2/RC | M2/CC |
|---|---|---|---|---|---|---|---|---|
| **LR1** | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 420 | 160 | 400 |
| GS | 20 | 170 | 20 | 90 | 16 | 136 | 16 | 72 |
| **LR2** | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 300 | 320 | 400 |
| GS | 40 | 170 | 40 | 90 | 32 | 136 | 32 | 72 |
| **LR3** | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 180 | 480 | 400 |
| GS | 60 | 170 | 60 | 90 | 48 | 136 | 48 | 72 |
| **LR4** | | | | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 | 0 | 420 | 400 |
| GS | 0 | 0 | 0 | 0 | 0 | 0 | 64 | 72 |

[a]Abbreviations used in this and the following spreadsheets: R = RAM failure end items, C = combat damaged end items, RC = RAM failure components, CC = combat damaged components.

## 5-4. DETERMINATION OF TRANSPORTATION WORKLOADS

a. The first step in converting manhours to transportation workloads is to make up a table of average repair times for end items (Table 5-3) using data provided by AMSAA (see Appendix E).

Table 5-3. Average Repair Times - End Items (automotive manhours)

| Type | M1/R | M1/C | M2/R | M2/C |
|---|---|---|---|---|
| DS | 5.1 | 23.93 | 10.7 | 11.73 |
| GS | 1.7 | 43.84 | 41.9 | 12.32 |

b. Using the M1/R through M2/C data from Table 5-2 and dividing the man-hour shortfall by the corresponding average repair time from Table 5-3 for end items yields the number of end items requiring transport (Table 5-4) each day.

Table 5-4. Manhours Converted to End Items

| LR | M1/R | M1/C | M2/R | M2/C | Total |
|---|---|---|---|---|---|
| LR1 | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 |
| GS | 12 | 4 | 1 | 8 | 26 |
| LR2 | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 |
| GS | 24 | 4 | 1 | 8 | 37 |
| LR3 | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 |
| GS | 36 | 4 | 21[a] | 8 | 48 |
| LR4 | | | | | |
| DS | 0 | 0 | 0 | 0 | 0 |
| GS | 0 | 0 | 0 | 0 | 0 |

[a]Totals vary due to rounding

c. End items requiring HETs will be moved on an item basis, and no further conversion prior to transport is required. Components and those end items not transported by HET require conversion to short tons prior to transport. A table of factors can be developed using AMSAA data (Appendix E) to convert shortfall to be transported from manhours into short tons (Table 5-5). The method used to determine these factors is explained in Appendix F.

For those end items requiring weight conversion, weight data is readily available in technical publications.

Table 5-5. Conversion Factors - Manhours to Short Tons

| Type | M1/RC | M1/CC | M2/RC | M2/CC |
|---|---|---|---|---|
| DS | 0.2289 | 7.4320 | 1.1100 | 1.1375 |
| GS | 0.0475 | 1.5332 | 0.0130 | 0.0983 |

d. Using the M1/RC through M2/CC data from Table 5-2 and multiplying the manhour shortfall by the corresponding conversion factor from Table 5-5 yields a transportation workload in short tons (Table 5-6).

Table 5-6. Manhours Converted to Short Tons

| LR | M1/RC | M1/CC | M2/RC | M2/CC | Total |
|---|---|---|---|---|---|
| LR1 | | | | | |
| DS | 0 | 3121 | 178 | 455 | 3754 |
| GS | 1 | 209 | 0 | 7 | 217 |
| LR2 | | | | | |
| DS | 0 | 2230 | 355 | 455 | 3040 |
| GS | 2 | 209 | 0 | 7 | 218 |
| LR3 | | | | | |
| DS | 0 | 1338 | 533 | 455 | 2326 |
| GS | 2 | 209 | 1 | 7 | 218 |
| LR4 | | | | | |
| DS | 0 | 0 | 466 | 455 | 921 |
| GS | 0 | 0 | 1 | 7 | 8 |

e. Combining Tables 5-4 and 5-6, the theater transportation workload per time period in items and short tons can be determined (Table 5-7). Note how the workload is distributed. All GS shortfall must move to logical region 4, the first region in which GS materiel can be repaired. DS materiel is moved to the next higher region for repair if capability allows.

Table 5-7. Movement Requirements

| From | Level to | | LR1 | LR2 | LR3 | LR4 | LR5 |
|---|---|---|---|---|---|---|---|
| LR1 | DS | Items | 0 | 0 | 0 | 0 | 0 |
| | | STON | 0 | 3754 | 0 | 0 | 0 |
| | GS | Items | 0 | 0 | 0 | 26 | 0 |
| | | STON | 0 | 0 | 0 | 217 | 0 |
| LR2 | DS | Items | 0 | 0 | 0 | 0 | 0 |
| | | STON | 0 | 0 | 3040 | 0 | 0 |
| | GS | Items | 0 | 0 | 0 | 37 | 0 |
| | | STON | 0 | 0 | 0 | 218 | 0 |
| LR3 | DS | Items | 0 | 0 | 0 | 0 | 0 |
| | | STON | 0 | 0 | 0 | 2326 | 0 |
| | GS | Items | 0 | 0 | 0 | 48 | 0 |
| | | STON | 0 | 0 | 0 | 218 | 0 |
| LR4 | DS | Items | 0 | 0 | 0 | 0 | 0 |
| | | STON | 0 | 0 | 0 | 0 | 921 |
| | GS | Items | 0 | 0 | 0 | 0 | 0 |
| | | STON | 0 | 0 | 0 | 0 | 8 |

f. The data above was derived from just two items, the M1 and the M2. The total workload for the theater including all items under consideration will be much larger. Table 5-8 represents such a theaterwide workload for use in illustrating how this workload might be converted to truck unit requirements.

Table 5-8. Total Movement Requirements

| From | Level to | | LR1 | LR2 | LR3 | LR4 | LR5 |
|---|---|---|---|---|---|---|---|
| LR1 | DS | Items | 0 | 160 | 0 | 0 | 0 |
| | | STON | 0 | 2500 | 0 | 0 | 0 |
| | GS | Items | 0 | 0 | 0 | 320 | 0 |
| | | STON | 0 | 0 | 0 | 5000 | 0 |
| LR2 | DS | Items | 0 | 0 | 100 | 0 | 0 |
| | | STON | 0 | 0 | 2000 | 0 | 0 |
| | GS | Items | 0 | 0 | 0 | 500 | 0 |
| | | STON | 0 | 0 | 0 | 6000 | 0 |
| LR3 | DS | Items | 0 | 0 | 0 | 50 | 0 |
| | | STON | 0 | 0 | 0 | 1700 | 0 |
| | GS | Items | 0 | 0 | 0 | 600 | 0 |
| | | STON | 0 | 0 | 0 | 6500 | 0 |
| LR4 | DS | Items | 0 | 0 | 0 | 0 | 20 |
| | | STON | 0 | 0 | 0 | 0 | 820 |
| | GS | Items | 0 | 0 | 0 | 0 | 40 |
| | | STON | 0 | 0 | 0 | 0 | 1600 |

g. In order to determine truck unit requirements, it is necessary to examine each logical region independently while considering the impact of rail. For purposes of this methodology, trips to a railhead will be considered local haul (20 miles or less), and trips between regions will be considered line haul (approximately 90 miles). The terms local haul and line haul are used in transportation planning as a basis for determining truck unit requirements. In Tables 5-9 through 5-12 which follow, the spreadsheet headings are abbreviated. The following key will assist in understanding the other headings used.

AFPDA rate: estimated percentage of the shortfall moving by rail based on the Army Force Planning Data and Assumptions (AFPDA). AFPDA provides a distribution by area of cargo movements by mode. The figures used in this methodology represent adjusted AFPDA values in that inland water and air are not considered for retrograde in this model.

Category: indicates the level of repair, GS or DS, and the type of shortfall requiring movement (end item or short tons).

From rail: this column refers to materiel which moves from the railhead to a maintenance facility for repair. Capacity must be present before the movement takes place, thus avoiding multiple handling.

To LR: indicates the destination of the shortfall; all GS materiel is initially destined for LR4, where the GS activities are located.

To move: the amount of shortfall eligible to be moved. In Chapter 3, when shortfall is determined, GS materiel moves in a cumulative manner from region to region to be repaired. This column allows for a determination of how much of that materiel is actually present at that location. GS materiel which has been loaded on rail reduces this total as well.

By rail: the proportion of the total shortfall eligible to move by rail using the AFPDA rate.

By hwy: the proportion of the total shortfall eligible to move by highway using the AFPDA rate.

To rail: the amount of shortfall moving to the railhead. All rail eligible shortfall does not move to the railhead, as the train may already have shortfall onboard. In that case, consideration is given to the onboard shortfall first to avoid multiple cargo handling.

Cumulative rail: the amount of shortfall moving by rail after loading (to rail) or offloading (from rail).

Local and line haul: These terms were previously explained.

h. In logical region 1, the division area (Table 5-9), there is no rail capacity. Therefore, all the materiel must be moved by highway from logical region 1 to logical region 2, where the materiel is either repaired or shipped further to the rear. All GS materiel is destined for logical region 4. Materiel moving between regions constitutes a line haul. Rail is not present in logical region 1, so there is no incoming materiel (the column entitled "From rail") from the rail head to be concerned about.

Table 5-9. Logical Region 1 Movement Requirements

| AFPDA rail rate = 0% <br> Shortfall | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | From rail | To LR2 | To LR4 | Total to move | By rail | By hwy | To rail | Cumulative rail | Local haul | Line haul |
| DS | | | | | | | | | | |
| Items | 0 | 160 | 0 | 160 | 0 | 160 | 0 | 0 | 0 | 160 |
| STON | 0 | 2500 | 0 | 2500 | 0 | 2500 | 0 | 0 | 0 | 2500 |
| GS | | | | | | | | | | |
| Items | 0 | 0 | 320 | 320 | 0 | 320 | 0 | 0 | 0 | 320 |
| STON | 0 | 0 | 5000 | 5000 | 0 | 5000 | 0 | 0 | 0 | 5000 |
| Total | | | | | | | | | | |
| Items | 0 | 160 | 320 | 480 | 0 | 480 | 0 | 0 | 0 | 480 |
| STON | 0 | 2500 | 5000 | 7500 | 0 | 7500 | 0 | 0 | 0 | 7500 |

i. In logical region 2, the corps (Table 5-10), rail is present. Sixty-five percent of shortfall will move by rail. Therefore, out of 600 items and 8,000 short tons, 390 items and 5,200 short tons are eligible to move by rail. To reduce multiple handling of damaged equipment, GS materiel is assigned to rail first, since it has to travel furthest (LR4). Any remaining rail capacity is allocated to DS materiel. In this case, there was not enough rail capacity to satisfy all of the GS requirement, so some GS and all DS materiel will move by highway from logical region 2 to logical region 3. This constitutes a line haul requirement while that materiel moving to the rail head will be considered a local haul. Rail is not present in logical region 1, so there is no incoming materiel (the column entitled "From rail") from the railhead to be concerned about.

Table 5-10. Logical Region 2 Movement Requirements

| AFPDA rail rate = 65% | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shortfall | | | | | | | | | | |
| Category | From rail | To LR3 | To LR4 | Total to move | By rail | By hwy | To rail | Cumu-lative rail | Lo-cal haul | Line haul |
| DS | | | | | | | | | | |
| Items | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 0 | 0 | 100 |
| STON | 0 | 2000 | 0 | 2000 | 0 | 2000 | 0 | 0 | 0 | 2000 |
| GS | | | | | | | | | | |
| Items | 0 | 0 | 500 | 500 | 390 | 110 | 390 | 390 | 390 | 110 |
| STON | 0 | 0 | 6000 | 6000 | 5200 | 800 | 5200 | 5200 | 5200 | 800 |
| Total | | | | | | | | | | |
| Items | 0 | 100 | 500 | 600 | 390 | 210 | 390 | 390 | 390 | 210 |
| STON | 0 | 2000 | 6000 | 8000 | 5200 | 2800 | 5200 | 5200 | 5200 | 2800 |

j. In logical region 3 (Table 5-11), 70 percent of the material can move by rail and is allocated as described above. In logical region 3, 182 items and 2,100 short tons of damaged materiel can move by rail. Note that only 210 items of GS materiel are available for movement, while logical region 3 has a shortfall of 600. This situation is created by the methodology of Chapter 4 used in determining shortfall. The amount of GS materiel in each region is cumulative. That is, the shortfall from the more forward region is added to the shortfall of the next region. In logical region 2, there were 500 GS items to repair, of which 390 were placed on a rail car for movement to logical region 4 where they could be repaired. The remaining 110 items moved by highway to logical region 3. As the quantity is cumulative, the amount of new GS damaged items is determined by subtracting the quantity short in logical region 2 from the quantity short in logical region 3. This gives a total of 100 new items (600-500). There are also the 110 GS-level damaged items that moved by highway present in region 3 for a net total of 210. The same problem does not exist for DS damaged materiel. DS damaged materiel moves from region to region where it is repaired or moved further to the rear as described in Chapter 3, and shortfall is determined. This constitutes the amount of materiel that must be moved from that region. Note that there is no movement from the railhead in logical region 3 as DS damaged materiel was not loaded on the train in logical region 2 and, as already mentioned, the GS materiel will remain with the train until logical region 4.

Table 5-11. Logical Region 3 Movement Requirements

| AFPDA rail rate = 70% Shortfall | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | From rail | To LR4 | Total to move | By rail | By hwy | To rail | Cumu-lative rail | Lo-cal haul | Line haul |
| DS | | | | | | | | | |
| Items | 0 | 50 | 50 | 0 | 50 | 50 | 50 | 50 | 50 |
| STON | 0 | 1700 | 1700 | 800 | 900 | 1700 | 1700 | 1700 | 900 |
| GS | | | | | | | | | |
| Items | 0 | 600 | 210 | 182 | 28 | 182 | 572 | 182 | 28 |
| STON | 0 | 6500 | 1300 | 1300 | 0 | 1300 | 6500 | 1300 | 0 |
| Total | | | | | | | | | |
| Items | 0 | 650 | 260 | 182 | 78 | 232 | 622 | 232 | 78 |
| STON | 0 | 8200 | 3000 | 2100 | 900 | 3000 | 8200 | 3000 | 900 |

k. Several changes occur in logical region 4 (Table 5-12). First, GS maintenance capability is present, resulting in the movement from the railhead of some of the GS materiel for repair. Note that there is movement of 40 GS items to the railhead due to a maintenance shortfall in logical region 4. As repair of GS materiel is taking place in logical region 4, using the cumulative approach already discussed, a true shortfall of GS damaged items exists in logical region 4. There are currently 572 GS damaged items on rail. To avoid multiple handling, there is no reason to move the 40 items short from the train. As a result, 532 items move from the train to the GS maintenance facility, while the others remain on rail for further transport to logical region 5. Damaged DS materiel which had been loaded in logical region 3 is offloaded in logical region 4 as well. That materiel which cannot be repaired in logical region 4 moves on to logical region 5.

Table 5-12. Logical Region 4 Movement Requirements

| AFPDA rail rate = 70% Shortfall | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | From rail | To LR5 | Total to move | By rail | By hwy | To rail | Cumu-lative rail | Lo-cal haul | Line haul |
| DS | | | | | | | | | |
| Items | 48 | 20 | 20 | 2 | 18 | 0 | 2 | 48 | 18 |
| STON | 1606 | 820 | 820 | 94 | 726 | 0 | 94 | 1606 | 726 |
| GS | | | | | | | | | |
| Items | 532 | 40 | 40 | 40 | 0 | 0 | 40 | 532 | 0 |
| STON | 4900 | 1600 | 1600 | 1600 | 0 | 0 | 1600 | 4900 | 0 |
| Total | | | | | | | | | |
| Items | 580 | 60 | 60 | 42 | 18 | 0 | 42 | 580 | 18 |
| STON | 6506 | 2420 | 2420 | 1694 | 726 | 0 | 1694 | 6506 | 726 |

1. The last step in the model is to accumulate all of the DS/GS damaged items and short tons scheduled to move by line or local haul prior to determining how many truck units will be required to satisfy the requirement. This information is summarized in Table 5-13.

Table 5-13. Summary of Movement Requirements

| Logical region | Items | | STON | |
|---|---|---|---|---|
| | Local | Line | Local | Line |
| LR1 | 0 | 480 | 0 | 7,500 |
| LR2 | 390 | 210 | 5,200 | 2,800 |
| LR3 | 232 | 78 | 3,000 | 900 |
| LR4 | 580 | 18 | 6,506 | 726 |

m. Table 5-14 illustrates how these workloads are easily converted into requirements for truck units. The transportation heavy equipment truck company, SRC55-729L10010, with 36 task vehicles, is capable of transporting 54 tank equivalents in line haul (90 miles) and 108 tank equivalents in a local haul (20 miles). The medium truck company, SCR55-727L10010, with 60 task vehicles, is capable of transporting 3,960 STON daily in local haul and 1,980 STON in a line haul move.

Table 5-14. Truck Unit Equivalents[a]

| Logical region | Items | | Total | STON | | Total |
|---|---|---|---|---|---|---|
| | Local | Line | | Local | Line | |
| LR1 | 0 | 9 | 9 | 0 | 4 | 4 |
| LR2 | 4 | 4 | 8 | 2 | 2 | 4 |
| LR3 | 2 | 1 | 3 | 1 | 1 | 2 |
| LR4 | 5 | 1 | 6 | 2 | 1 | 3 |
| Total | | | 26 | | | 13 |

[a]All numbers rounded up.

5-5. **SUMMARY.** This chapter has presented a methodology for determining transportation workloads, by area, over time within a theater of operations. The methodology is dependent upon AMSAA-provided data for average time of repair and weight per component and the definition of TOE capabilities at various logical regions.

# CHAPTER 6

## OTHER REARWARD MOVEMENTS (EEA 5)

**6-1. INTRODUCTION.** In the theater of operations, rearward movements are not limited to damaged materiel. Many other rearward movements of personnel and cargo are occurring at the same time, utilizing the same types of transportation assets required for the movement of damaged materiel. Retrograde must compete with these other movements of cargo and personnel for limited transportation assets. This chapter describes methodologies for identifying the workloads associated with some of these other rearward movements.

**6-2. GENERAL**

**a.** In the previous Retrograde Study, 11 major categories of rearward movements were identified, as shown in Table 6-1.

**Table 6-1. Other Rearward Movements**

| |
|---|
| Unit Moves |
| Enemy Prisoners of War |
| Medical Evacuation |
| Killed in Action |
| Mail |
| Rearward Movement of Ammo Stocks |
| Noncombatant Evacuation |
| Rearward Movement of Supply Stocks |
| Denial Operations |
| Captured Enemy Materiel |
| Critical Strategic Materials |

**b.** This study examines medical evacuation, enemy prisoners of war, mail, killed in action, and unit moves. Each of these categories can be represented in the model using currently available models and data.

**c.** The rearward movement of ammunition is not examined because it was felt that trucks dedicated to the movement of ammunition would be utilized for rearward movements (Chap 1, para 7d).

**d.** Noncombat evacuation is assumed completed.

**e.** The remaining four categories were not examined due to a current lack of data on which to base estimates. The overall methodology of the study is readily adaptable to the addition of any or all of these movements, should additional data become available.

## 6-3. UNIT MOVES

a. Unit moves can occur at any time--in any direction. Most units are not capable of transporting all of their personnel and equipment when movement is required. As a result, unit moves require a large number of transportation assets. In the FASTALS Model, this data is referred to as the nonmobile weight and is one of the inputs included in the master file.

b. Using FASTALS, it is possible to estimate the transportation workload generated by unit moves.

c. FASTALS divides the theater into logical and physical regions as shown in Figure 6-1. There are 6 logical regions and 21 physical regions. Units located in a logical region are placed in the foremost physical region.

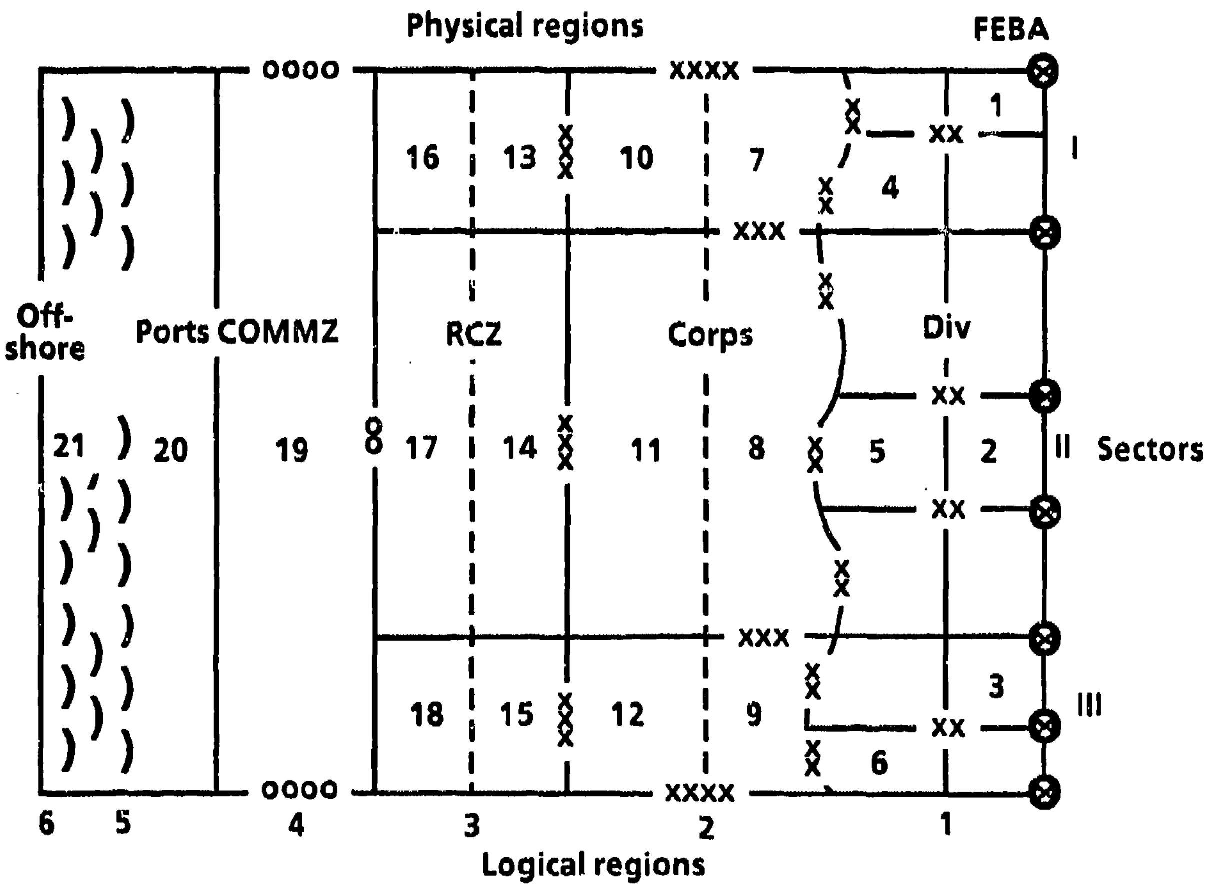


Figure 6-1. FASTALS Theater Map

d. The R-table, a FASTALS output shown in Figure 6-2, gives the location of each logical region in terms of physical region over time. Rearward movement of the forward edge of the battle area results in the collapse of forward physical regions. From the Figure 6-2, physical regions which have collapsed can be determined. For example, in time period 3, physical regions 1, 3, and 6 have collapsed (gone to 0) in the division area.

DIVISION = 1    COMMZ = 4
CORPS = 2    PORTS = 5
REAR CZ = 3    OFF SHORE = 6

| TIME PERIOD | PHYSICAL REGION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 3 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 4 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 5 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 8 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 9 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 10 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |
| 11 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 5 | 6 |

Figure 6-2. FASTALS R-table

e. If a physical region collapses, units located in that region must relocate to a region further to the rear as indicated in Figure 6-3.

| Physical region | Next highest physical regions |
|---|---|
| 1 | 4-7-10-13-16 |
| 2 | 5-8-11-14-17 |
| 3 | 6-9-12-15-18 |

Figure 6-3. Collapse of Physical Regions

f. The FAS report (another FASTALs output) currently accumulates population data for units located in each physical region over time using input data from the FASTALS master file. A similar report can be generated which accumulates nonmobile weights (also in the master file) for each unit located in a physical region. A sample population report is provided as Figure 6-4. As physical regions collapse over time, the units are moved back, with the result that population figures from the collapsed regions are added to the population of the regions further to the rear. The population in a collapsed region decreases to zero from one time period to the next. The difference between a positive population figure in one time period and the next time period when this figure drops to zero represents a movement of people. For example, in Figure 6-4, (in time period 2), physical region 1 has 42,823 people. In time period 3, the same region has none. Therefore, the 42,823 people have moved from physical region 1 to physical region 4 as required by Figure 6-3. Physical region 4, which had no people in time period 2, now has a population of 43,363. The difference between 42,823 and 43,363 is attributable to newly arrived units. The same approach using nonmobile weights will yield a transportation workload in short tons for each physical

region. Accumulating the workload for the physical regions in a logical region gives the total transportation workload (for unit moves) for each logical region. Table 6-2 shows how such a workload in short tons (STON) might appear.

TAA96NATO SCENARIO (16 SEP 88) 90 DAY(DESIGN CASE) **UNCLASS**
PHYSICAL REGIONS---WORKLOAD 1 AFTER CYCLE 13
U.S. ARMY POPULATION IN THOUSANDS

| | TIME PERIOD | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REGION | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 19.615 | 42.823 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 2 | 50.849 | 63.907 | 62.557 | 63.188 | 100.093 | .000 | .000 | .000 | .000 | .000 | .000 |
| 3 | 69.192 | 113.273 | .000 | 154.057 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4 | .000 | .000 | 43.363 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5 | .000 | .000 | .000 | .000 | .000 | 111.898 | .000 | 99.128 | 101.178 | 102.079 | 102.720 |
| 6 | .000 | .000 | .000 | .000 | 192.616 | .000 | .000 | .000 | .000 | .000 | 178.933 |
| 7 | 13.968 | 28.559 | 34.942 | 44.788 | 86.390 | .000 | .000 | .000 | .000 | .000 | .000 |
| 8 | 19.561 | 36.123 | 42.662 | 44.439 | 50.432 | 59.369 | 102.176 | 60.931 | 61.258 | 61.292 | 61.688 |
| 9 | 23.100 | 48.983 | 114.226 | 77.229 | 66.274 | 193.317 | 177.706 | 174.519 | 177.287 | 178.933 | 107.139 |
| 10 | .000 | .000 | .000 | 36.906 | 44.788 | 106.123 | 97.344 | 95.845 | 96.961 | 98.198 | 98.810 |
| 11 | .000 | .000 | .000 | .000 | .000 | .000 | 60.931 | .000 | .000 | .000 | .000 |
| 12 | .000 | .000 | 64.379 | .000 | .000 | 104.212 | 105.389 | 105.676 | 106.844 | 107.130 | .000 |
| 13 | 9.634 | 20.652 | 21.646 | 22.610 | 23.572 | 57.148 | 56.180 | 58.322 | 58.459 | 58.629 | [illegible] |
| 14 | 4.315 | 11.594 | 13.449 | 13.835 | 14.614 | 15.405 | 15.602 | 15.602 | 15.644 | 15.954 | 15.954 |
| 15 | 4.350 | 11.333 | 13.583 | 14.716 | 15.510 | 15.865 | 15.870 | 15.870 | 15.960 | 16.162 | 16.339 |
| 16 | .000 | .000 | .000 | .000 | .000 | 24.809 | 24.900 | 24.900 | 24.998 | 25.083 | 25.083 |

Figure 6-4. US Army Population in Thousands by Physical Region

Table 6-2. Unit Moves (STON)

| Time period | LR1 | LR2 | LR3 | LR4 | LR5 |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |
| 3 | 20,000 | 0 | 0 | 0 | 0 |
| 4 | 40,000 | 20,000 | 0 | 0 | 0 |
| 5 | 60,000 | 40,000 | 20,000 | 0 | 0 |
| 6 | 100,000 | 80,000 | 60,000 | 0 | 0 |

g. Using a line haul capacity of 1,350 short tons per day for a medium truck company (SRC 55-728L10010), it is an easy matter to convert the workloads of Table 6-2 into truck unit requirements as given in Table 6-3.

Table 6-3. Truck Companies Required ( for unit moves)

| Time period | LR1 | LR2 | LR3 | LR4 | LR5 |
|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 14.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 29.6 | 14.8 | 0.00 | 0.00 | 0.00 |
| 5 | 44.4 | 29.6 | 14.8 | 0.00 | 0.00 |
| 6 | 74.1 | 59.3 | 44.4 | 0.00 | 0.00 |

## 6-4. ENEMY PRISONERS OF WAR

a. According to doctrine, enemy prisoners of war (EPWs) are to be evacuated from the forward areas as soon as possible.

b. Using FASTALS, it is possible to estimate the transportation workload generated by EPWs.

c. Assumptions

(1) EPWs are captured in logical region 1.

(2) EPWs are moved from logical region 1 to logical region 2, then from 2 to logical region 4. (This assumption is based on observation of workload 15 as accumulated within FASTALS (see Table 6-4).)

(3) The prisoner of war camp will be located in logical region 4.

d. EPWs are accumulated by region and time period and shown in workload 15 for each time period. This information can be found in the FAS, a FASTALS output report. Table 6-4 is extracted from a workload 15 summary.

Table 6-4. Enemy Prisoners of War

| Region | Time period | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 0 | 277 | 793 | 915 | 961 | 1459 | 1364 |
| 2 | 0 | 0 | 0 | 450 | 750 | 750 | 1350 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 450 | 1200 | 1950 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

e. Examining Table 6-4, time period 5, the following observations can be made:

(1) Nine hundred sixty-one EPWs are being held in logical region 1.

(2) Four hundred fifty EPWs were moved from logical region 2 to 4. There were no EPWs present in region 4 during time period 4.

(3) Seven hundred fifty EPWs were moved from logical region 1 to 2. There are 750 EPWs present in logical region 2. In the previous time period, there had been 450, but these have moved to logical region 4. Therefore, the 750 total represents new arrivals.

f. Examining Table 6-4, time period 6, the following observations can be made:

(1) One thousand four hundred fifty-nine EPWs are being held in logical region 1.

(2) Seven hundred fifty EPWs were moved from logical region 2 to 4. Subtract logical region 4, time period 5, from logical region 4, time period 6, (i.e., 1,200 - 450).

(3) Seven hundred fifty EPWs were moved from logical region 1 to 2. Seven hundred fifty EPWs were present, 750 were moved, and 750 are still present; therefore, 750 new arrivals must have come from logical region 1.

g. EPWs moving into, from, or within a region constitute a movement requirement. Summarizing the observations of paragraphs 6-4e and f above, movement requirements for time periods 5 and 6 can be determined for EPWs as shown in Table 6-5. The 1,200 EPWs moved in time period 5 within logical region 2 represent the 450 EPWs moving out of the region and the 750 EPWs moving into the region. Logical region 3, as a transit region between 2 and 4, accumulates the workload for all EPWs transiting the region.

Table 6-5. Enemy Prisoner of War Movement Requirements

| Logical region | Time period | |
|---|---|---|
| | 5 | 6 |
| 1 | 750 | 750 |
| 2 | 1200 | 1500 |
| 3 | 450 | 750 |
| 4 | 450 | 750 |

h. Using a line haul capacity of 4,500 passengers for a medium truck company (SRC 55-727L10010), it is an easy matter to convert the workloads of Table 6-5 into truck unit requirements as shown in Table 6-6. The truck unit requirements, while small (portions of truck companies), are measurable.

Table 6-6. Truck Unit Requirements (EPWs)

| Time period | LR1 | LR2 | LR3 | LR4 | LR5 |
|---|---|---|---|---|---|
| 5 | 0.17 | 0.27 | 0.10 | 0.10 | 0.00 |
| 6 | 0.17 | 0.34 | 0.17 | 0.17 | 0.00 |

## 6-5. MEDICAL EVACUATION

a. Medical evacuation is the timely, efficient movement of sick, injured, or wounded persons from the battlefield and other locations to medical treatment facilities and from these facilities to other facilities further to the rear. Evacuation begins at the location where the injury or illness occurs and continues as far rearward as the patient's medical condition warrants or the military situation requires.

b. Within a theater of operations, patients may be evacuated by medical evacuation units or by theater transportation units when medical evacuation channels prove to be inadequate.

c. Using FASTALS, the Wartime Manpower Planning System (WARMAPS), and the Patient Flow Model (PFM), it is possible to estimate the transportation workload generated by medical evacuation.

d. Casualty rates presented in WARMAPS, when combined with population data, generate hospital admitted casualties for wounded in action (WIA) and disease and nonbattle injury (DNBI) personnel. The PFM simulates the flow of these in-patients through a multiechelоned hospitalization system, determining patient disposition.

e. The PFM locates hospitals in the corps and COMMZ. Data is given for the division, corps, and COMMZ only. For purposes of the study, the different areas of the theater, as designated within the different models, are matched as portrayed in Table 6-7. Therefore, the hospitals are located in logical regions 2 and 4.

f. Using PFM, the number of WIA and DNBI that need to go to the hospital for each time period in each logical region can be identified as shown in Tables 6-8 and 6-9. The total number of personnel requiring transport to the hospital is included as Table 6-10. These personnel make up the total evacuation requirement for this study (Table 6-10). WIA and DNBI personnel who go to aid stations are ignored by the model. Movement of these personnel should be accomplished by unit-level transportation capability.

**Table 6-7. Medical Theater of Operations**

| Patient Flow Model | WARMAPS | FASTALS (retrograde) |
|---|---|---|
| Echelon 1, Region 1 | Division | Logical Region 1 |
| Echelon 1, Region 2 | Corps | Logical Region 2 |
| | | Logical Region 3 |
| | COMMZ | Logical Region 4 |

g. WIA and DNBI occurring in logical regions 1 and 2 go to hospitals located in logical region 2. Those occurring in logical regions 3 and 4 go to the hospital located in logical region 4.

Table 6-8. WIA to Hospital

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0 | 13,198 | 10,931 | 12,665 | 27,044 |
| 2 | 0 | 1,605 | 1,815 | 2,103 | 2,440 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 541 | 612 | 676 | 693 |

Table 6-9. DNBI to Hospital

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 1,900 | 3,970 | 3,928 | 4,867 | 7,747 |
| 2 | 769 | 1,113 | 1,259 | 1,459 | 1,973 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 595 | 773 | 875 | 966 | 1,154 |

Table 6-10. Total Patients to Move

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 1,900 | 17,168 | 14,859 | 17,532 | 34,791 |
| 2 | 769 | 2,718 | 3,074 | 3,562 | 4,413 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 595 | 1,314 | 1,487 | 1,642 | 1,847 |

h. The total number of medical evacuation units required can be determined from FASTALS. Tables 6-11 and 6-12 show typical requirements for such units to move the same volume of patients. FASTALS generates these requirements based on the existence of other units such as headquarters units,

divisions, etc. FASTALS creates these units in logical regions 2 and 4; however, air and surface ambulances are capable of providing evacuation support to more than one region. For purposes of this study, evacuation units in logical region 2 will support units located in logical regions 1 and 2, and medical evacuation units in logical region 4 will support units located in regions 3 and 4. Priority of support will be to the more forward unit.

**Table 6-11. SRC 08447 Air Ambulance Company Requirements (FASTALS)**

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 2 | 0 | 16 | 17 | 21 | 32 |
| 4 | 0 | 3 | 3 | 3 | 3 |

**Table 6-12. SRC 08449 Ambulance Company Requirements (FASTALS)**

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 2 | 0 | 11 | 12 | 15 | 23 |
| 4 | 0 | 3 | 3 | 3 | 3 |

i. Field Manual 8-55, Planning for Health Service Support, provides a formula for determining the number of evacuation units required to support the movement of patients. The formula is as follows:

$$\frac{(A \times B)}{C} + D \times E = \textit{ambulance requirements by type per day}$$

where:

- A = The total patients (WIA or DNBI) generated for a specific operation per day.

- B = The percentage of those patients in A above requiring evacuation. Normally, this figure will exceed 100 percent as a recognition of the fact that many patients will need to be moved more than once. The number of times a patient will be moved will depend on many factors. In assigning a specific percentage as a planning factor, the planner must consider:

    - Terrain.

    - Force structure.

    - Enemy weapons systems.

    - Weather.

    - Airfield or seaport locations.

    - Other factors affecting patient flow.

- C = The average number of patients moved by a means of evacuation. The figure will vary depending on the type of ambulance (ground or air) or the specific model of vehicle.

- D = The average number of missions a particular evacuation vehicle can complete per day.

- E = The dispersion allowance for the specific types of evacuation vehicles in the formula. The dispersion allowance is a recognition that a specific percentage of vehicles in the force will be unavailable for missions due to maintenance, crew rest, combat loss, or replacement lag time. The planner will determine the specific percentage used by reviewing maintenance historical data and considering the threat in terms of the enemy, terrain, and weather.

j. The formula can be rearranged algebraically to determine the capacity of a single unit as follows:

$$A = (C \times D \times E)/B$$

where: A = the total capability of a single unit.
C = the average movement capability of a unit

k. Table 6-13 provides the data used in this example. The movement capability and the evacuation capability of each company can be determined from the TOEs. A basic assumption is made that the patients to be transported are equally divided between litter and ambulatory patients. The other factors can vary and therefore are excellent candidates for sensitivity analysis. Dispersion factors were found in the Patient Flow Model with a rate of 1.25 for the division area, 1.25 for the corps, and 1.15 for the COMMZ.

Table 6-13. Medical Evacuation Formula Data

**Passenger capability**

| SRC | Litter | Ambulatory | Average |
|---|---|---|---|
| 08447 | 60 | 105 | 82.5 |
| 08449 | 160 | 320 | 240 |

**Average trips per day**

| | |
|---|---|
| Air = | 6 |
| Ground = | 2 |

**Dispersion factor**

| | |
|---|---|
| Region 1 | 1.25 |
| Region 2 | 1.25 |
| Region 3 | 1.15 |
| Region 4 | 1.15 |

Patients requiring evacuation = 150%

1. After determining the capability per unit as described above, the medical evacuation capability by logical region can be determined. Multiplying unit capability by the number of units gives total capability as shown in Tables 6-14, 6-15, and 6-16.

Table 6-14. SRC 08447 Air Ambulance Company Capability (FASTALS)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 2 | 0 | 6,600 | 7,013 | 8,663 | 13,200 |
| 4 | 0 | 1,139 | 1,139 | 1,139 | 1,139 |

Table 6-15. SRC 08449 Ambulance Company Capability (FASTALS)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 2 | 0 | 4,400 | 4,800 | 6,000 | 9,200 |
| 4 | 0 | 1,104 | 1,104 | 1,104 | 1,104 |

Table 6-16. Total Medical Evacuation Capability (FASTALS)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Local region 2 | | | | | |
| 08447 | 0 | 6,600 | 7,013 | 8,663 | 13,200 |
| 08449 | 0 | 4,400 | 4,800 | 6,000 | 9,200 |
| LR2 total | 0 | 11,000 | 11,813 | 14,663 | 22,400 |
| Local region 4 | | | | | |
| 08447 | 0 | 1,139 | 1,139 | 1,139 | 1,139 |
| 08449 | 0 | 1,104 | 1,104 | 1,104 | 1,104 |
| LR4 total | 0 | 2,243 | 2,243 | 2,243 | 2,243 |

m. Comparing evacuation capability to evacuation requirements by priority may lead to a shortfall, as shown in Table 6-17. Note again that evacuation units from logical region 2 support logical region 1 as well and that units from logical region 4 support logical region 3 as well.

Table 6-17. Medical Evacuation (shortfall)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Requirements | | | | | |
| LR1 | 1,900 | 17,168 | 14,859 | 17,532 | 34,791 |
| LR2 | 769 | 2,718 | 3,074 | 3,562 | 4,413 |
| LR3 | 0 | 0 | 0 | 0 | 0 |
| LR4 | 595 | 1,314 | 1,487 | 1,642 | 1,847 |
| Capability | | | | | |
| LR1 | 0 | 0 | 0 | 0 | 0 |
| LR2 | 0 | 11,000 | 11,813 | 14,663 | 22,400 |
| LR3 | 0 | 0 | 0 | 0 | 0 |
| LR4 | 0 | 2,243 | 2,243 | 2,243 | 2,243 |
| Satisfied | | | | | |
| LR1 | 0 | 11,000 | 11,813 | 14,663 | 22,400 |
| LR2 | 0 | 0 | 0 | 0 | 0 |
| LR3 | 0 | 0 | 0 | 0 | 0 |
| LR4 | 0 | 1,314 | 1,487 | 1,642 | 1,847 |
| Shortfall | | | | | |
| LR1 | 1,900 | 6,168 | 3,047 | 2,870 | 12,391 |
| LR2 | 769 | 2,718 | 3,074 | 3,562 | 4,413 |
| LR3 | 0 | 0 | 0 | 0 | 0 |
| LR4 | 595 | 0 | 0 | 0 | 0 |

n. Using a line haul capacity of 4,500 passengers for a medium truck company (SRC 55-727L10010), it is an easy matter to convert the workloads (shortfalls) of Table 6-17 into truck unit requirements as shown in Table 6-18.

Table 6-18. Truck Units Required (medical evacuation)

| | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| LR1 | 0 | 1 | 1 | 1 | 3 |
| LR2 | 0 | 1 | 1 | 1 | 1 |
| LR3 | 0 | 0 | 0 | 0 | 0 |
| LR4 | 0 | 0 | 0 | 0 | 0 |

## 6-6. KILLED IN ACTION

**a.** It has long been American military policy that the dead be returned for honorable burial whenever possible. For purposes of this study, it will be assumed that the dead will be evacuated from the theater operations to CONUS.

**b.** The casualty estimation process extracts the combined total number of killed, captured, and missing in action (KCMIA) for logical regions 1, 2, and 4 (Table 6-19) from the division-level (conventional warfare) combat simulation model. The following data were extracted from the CEM combat simulation for the OMNIBUS-89 Allied Forces, Central Europe scenario over a 60-day period.

(1) Fraction of KCMIA, killed in action (KIA): 78.3 percent

(2) Fraction of KCMIA, missing in action (MIA): 21.7 percent

At echelons above division, all personnel in the KCMIA category are considered KIA. Using this data, Table 6-20 gives the KIA by logical region and time period.

Table 6-19. Total Killed and Missing in Action

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0 | 0 | 6,709 | 5,438 | 6,873 |
| 2 | 2 | 4 | 412 | 470 | 590 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 153 | 179 | 166 |
| 5 | 0 | 0 | 0 | 0 | 0 |

Table 6-20. Total Killed in Action

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0 | 0 | 5,253 | 4,258 | 5,382 |
| 2 | 2 | 4 | 412 | 470 | 590 |
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 153 | 179 | 166 |
| 5 | 0 | 0 | 0 | 0 | 0 |

c. KIA in forward areas will move through logical regions located to their rear as they are evacuated. Thus, the evacuation workload for any region will be made up of the deaths in that region and the cumulative total of deaths occurring forward of that region (Table 6-21).

Table 6-21. Total Killed in Action (cumulative)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0 | 0 | 5,253 | 4,258 | 5,382 |
| 2 | 2 | 4 | 5,665 | 4,728 | 5,972 |
| 3 | 2 | 4 | 5,665 | 4,728 | 5,972 |
| 4 | 2 | 5 | 5,818 | 4,907 | 6,138 |
| 5 | 2 | 5 | 5,818 | 4,907 | 6,138 |

d. In Field Circular (FC) 21-451, I am the American Soldier, the average weight of an American soldier is calculated to be 158.9 pounds. Multiplying this average weight times the number of KIA and dividing by 2,000 gives a transportation workload in STON over time by area (Table 6-22).

Table 6-22. Total Killed in Action (STON)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0 | 0 | 417 | 338 | 428 |
| 2 | 0 | 0 | 450 | 376 | 474 |
| 3 | 0 | 0 | 450 | 376 | 474 |
| 4 | 0 | 0 | 462 | 390 | 488 |
| 5 | 0 | 0 | 462 | 390 | 488 |

e. Using a line haul capacity of 1,350 short tons for a medium truck company (SRC 55-728L10010), it is an easy matter to convert the KIAs to be evacuated (Table 6-22) into truck unit requirements, as shown in Table 6-23. While the quantities in this example are small, they are still measurable and should be considered as a part of this model. This is an estimation process and does not take into account that the dead are not cargo and will be treated with respect. For example, it is not likely that the bodies will be stacked, thereby reducing the capability of transport units.

Table 6-23. Truck Units Required (KIA)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0.000 | 0.000 | 0.31 | 0.25 | 0.32 |
| 2 | 0.000 | 0.000 | 0.33 | 0.28 | 0.35 |
| 3 | 0.000 | 0.000 | 0.33 | 0.28 | 0.35 |
| 4 | 0.000 | 0.000 | 0.34 | 0.29 | 0.36 |
| 5 | 0.000 | 0.000 | 0.34 | 0.29 | 0.36 |

## 6-7. MAIL OFFSET

a. In past wars, the mail has continued to move both to and from the theater of operations.

b. Field Manual 101-10-1 provides factors based on population and conflict intensity for the forward movement of mail (Table 6-24). These factors include the movement of official and personal mail within a theater of operations. For purposes of illustration, the worst case factor (low intensity) of .96 will be used, and the assumption will be made that the rearward flow of mail equals the forward flow.

**Table 6-24. Wartime Mail Factors to the European Theater**

| | Combat intensity | | |
|---|---|---|---|
| | High | Medium | Low |
| Pounds per man per day: | .24 | .36 | .96 |

c. An extract of FASTALS population figures as available in the FAS report, workload 1, is provided in Table 6-25.

**Table 6-25. FASTALS Population Data**

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 139,706 | 223,769 | 224,550 | 270,357 | 394,124 |
| 2 | 57,029 | 121,182 | 158,773 | 181,265 | 211,388 |
| 3 | 18,469 | 48,664 | 57,496 | 60,252 | 64,097 |
| 4 | 23,203 | 55,055 | 70,036 | 76,765 | 83,920 |
| 5 | 193 | 2,019 | 2,816 | 3,135 | 4,055 |

d. Multiplying the population by the factor (Table 6-24) provides the number of pounds of mail to be moved rearward by logical region over time (Table 6-26).

Table 6-26. Weight in Pounds of Mail to be Evacuated

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 134,118 | 214,818 | 215,568 | 259,543 | 378,359 |
| 2 | 54,748 | 116,335 | 152,422 | 174,014 | 202,932 |
| 3 | 17,730 | 46,717 | 55,196 | 57,842 | 61,533 |
| 4 | 22,275 | 52,853 | 67,235 | 73,694 | 80,563 |
| 5 | 185 | 1,938 | 1,938 | 3,010 | 3,893 |

e. The mail in the forward areas moves through each logical region as it moves rearward. Therefore, the workload is added to the workload of these regions as the mail moves rearward (Table 6-27).

Table 6-27. Cumulative Weight of Mail to be Evacuated (STON)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 67 | 107 | 108 | 130 | 189 |
| 2 | 94 | 166 | 184 | 217 | 291 |
| 3 | 103 | 189 | 212 | 246 | 321 |
| 4 | 114 | 215 | 245 | 283 | 362 |
| 5 | 115 | 216 | 247 | 284 | 364 |

f. Using a line haul capacity of 1,350 short tons for a medium truck company (SRC 55-728L10010), it is an easy matter to convert the short tons of mail to be evacuated (Table 6-27) into truck unit requirements as shown in Table 6-28.

Table 6-28. Truck Units Required (mail)

| Region | Time period | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | 0.05 | 0.08 | 0.08 | 0.10 | 0.14 |
| 2 | 0.07 | 0.12 | 0.14 | 0.16 | 0.22 |
| 3 | 0.08 | 0.14 | 0.16 | 0.18 | 0.24 |
| 4 | 0.08 | 0.16 | 0.18 | 0.21 | 0.27 |
| 5 | 0.08 | 0.16 | 0.18 | 0.21 | 0.27 |

**6-8. SUMMARY.** This chapter has provided methods for estimating the amount of truck units required to move units, enemy prisoners of war, wounded, killed in action, and mail using data from many sources.

# CHAPTER 7

# FORCE STRUCTURE (EEA 6)

**7-1. INTRODUCTION.** This chapter describes a methodology for including the movement of retrograde materiel within the theater of operations in the present force structure process.

## 7-2. GENERAL

**a.** The FASTALS Model is used by the US Army Concepts Analysis Agency (CAA) in determining Army combat service support (CSS) force structure. In order to represent the movement of retrograde materiel within the theater of operations, the current method of determining truck unit requirements must be modified to include transportation workloads created by shortfalls in maintenance capability. In Chapter 5, a methodology was given for determining a transportation workload in terms of short tons (medium truck unit requirements) and heavy lift items (heavy truck unit requirements).

**b.** In this study, the assumption is made that truck units are capable of being backloaded with retrograde materiel. That is, the total number of truck units eligible for movement of retrograde materiel rearward is equal to the number of units located in that region.

**c.** A detailed description of the method of incorporating retrograde in the force structure process is described in subsequent paragraphs. In brief, the method is as follows:

(1) The total number of eligible units is reduced by the number of units obligated to move ammunition (assumption 5), competing rearward movements (Chapter 6), and a factor provided by the transportation proponent based on diminished capability.

(2) The number of units required for movement of retrograde is determined.

(3) The net eligible units as determined in step 1 above are compared to the number of units required for movement of retrograde. If a shortfall exists, a requirement for an additional truck unit is added to the force structure.

## 7-3. TERMINOLOGY

**a.** Logical region (LR) - in order to simulate a wartime theater of operations, the FASTALS Model divides the theater into six logical regions. Logical region 1 represents the division area, logical region 2 the corps, logical region 3 the rear combat zone, and logical region 4 the communications zone.

**b.** Offset factor - term used in this study to refer to the percentage of rearward moving truck units not available for transport of retrograde.

c. Other rearward movements - term used in this study to refer to movements other than retrograde moving rearward in a theater of operations which compete with retrograde for scarce transportation assets.

## 7-4. OFFSET FACTOR

a. It has long been assumed that the full capability of transportation units moving forward would be available for the movement of damaged materiel rearward within the theater of operations. In fact, this is not the case. There are other factors that must be considered. Three elements that reduce the overall transportation unit capability for movement of retrograde within the theater of operations:

- The units are not made available for retrograde.
- The units may be engaged in another mission.
- Units engaged in retrograde may operate at diminished capacity.

b. The tactical situation and the guidance of the theater commander will determine how many of the truck units eligible for movement of retrograde actually participate in retrograde movements. For example, in this study, the assumption has been made that ammunition movement is critical to the war effort. Delay of transportation units moving ammunition for backloading of damaged materiel is not allowed. Such a decision by a theater commander (in this case, the study sponsor) would not be unusual considering the tactical situation. Those units used for movement of ammunition therefore reduce the overall number of truck units eligible for movement of retrograde materiel. Using the Analysis of Logistic Factors Study (ALOGFACS) methodology, it is possible to estimate the amount of ammunition required to be transported by truck units in each logical region for each time period. For example, in logical region 1, FASTALS determines a requirement for 20 medium truck units. Using the ALOGFACS methodology, it is determined that two transportation units are needed for movement of ammunition. Therefore 10 percent of the logical region 1 transportation units are not available for movement of retrograde materiel.

c. In the Wartime Retrograde of Damaged Materiel from a Theater of Operations (RETRO I) Study, a number of other rearward movements occurring in a theater was identified. Each of these movements requires transportation assets. Units engaged in other rearward movements are not available for movement of retrograde materiel. In Chapter 6, methods were given for estimating the number of units required for movement of other rearward cargo. The total number of truck units required for moving wounded, killed in action, unit moves, mail, and prisoners of war reduces the number of units eligible for movement of retrograde materiel. Comparing the total number of units required for other rearward movements to the total number of units required as determined by FASTALS, a percentage can be determined. For example, in logical region 1, FASTALS determines a requirement for 20 medium truck units. Using the methods of Chapter 6, it is determined that two units are needed for other rearward movements. Therefore, 10 percent of the logical region 1 transportation units available are not available for movement of retrograde materiel.

d. The movement of retrograde materiel is not an easy process. Transportation units pay a price in time for transporting damaged materiel. Damaged materiel can require longer to offload or load. Damaged materiel may not be located where the forward moving unit has dropped resupply cargo. Upon return, the maintenance facility may not be collocated with the resupply loading activity. Movement of damaged materiel may have an impact on the speed with which a truck unit may travel over the road. The net result is a diminished overall capacity of a truck unit to move cargo forward. The actual reduction in capacity must be determined by the proponent for transportation. CAA has requested such an estimate from the Transportation School. For purposes of this study, it will be assumed that a response has been received, and the diminished capability of the truck units due to movement of retrograde is 5 percent.

e. Combining the three offsets to units eligible for retrograde as determined above gives a total of 25 percent. Therefore, in this example, only 75 percent of the units eligible for retrograde movement are actually available to move retrograde.

## 7-5. FASTALS NOW

a. In general, FASTALS determines force structure requirements as shown in Figure 7-1. FASTALS receives input from the CEM combat simulation. Using the data provided by CEM, FASTALS performs various calculations which create workloads. A proponent provides factors which convert workloads into requirements for transportation units.

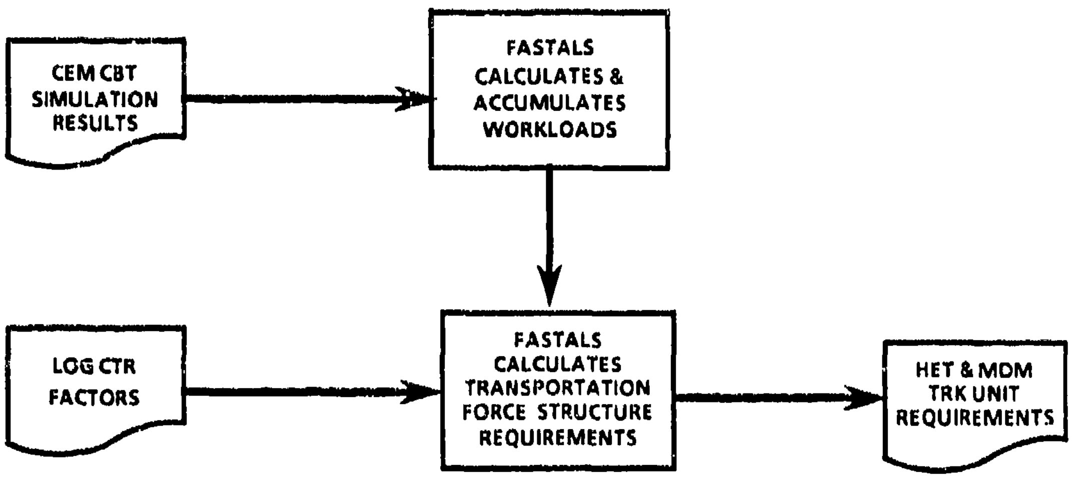


Figure 7-1. Transportation Force Structure - FASTALS Now

b. Internally, the FASTALS Model determines truck unit requirements as shown in Figure 7-2.

(1) The number of host nation units available is manually input under unit identification number (UIN) 891.

(2) In this example, the total number of truck units required is calculated based on the requirement to move dry cargo and unit equipment (workload 18) as determined within the model using the rules established by the proponent. In this case, for every unit of workload 18 in logical region 1, .074 medium truck units are required in logical region 1. The total number of truck units required is accumulated as UIN 892 dummy medium truck company.

(3) Comparing the total number of units required to the total number of units provided by the host nation yields a requirement for US Army truck units (UIN 894). If the comparison yields a requirement for negative or 0 truck units, the results are ignored. If a requirement exists for additional US truck units, then the units are added to the force structure process, and FASTALS continues to cycle until all requirements are identified.

CALCULATION OF LR2 MDM TRUCK CGO (55728L1) REQUIREMENTS:

| UIN | UNIT | BASIS FOR EXISTENCE |
|---|---|---|
| 891 | HN MDM TRK CO | MANUAL INPUT |
| 892 | DUMMY MDM TRK CO | .074 PER WKL 18* IN LR1<br>.044 PER WKL 18 IN LR2 |

US REQUIREMENTS ARE BASED ON:

| | | |
|---|---|---|
| 894 | US MDM TRK CO | + 1 PER UNIT 892<br>- 1 PER UNIT 891 |

*WKL 18 1000 STON HOURS DRY CARGO & UNIT EQUIP / TRUCK / DAY

Figure 7-2. FASTALS Now

## 7-6. PROPOSED MODIFICATION OF FASTALS

a. In order to include the movement of retrograde materiel in the force structure process, the changes shown in Figure 7-3 are proposed. FASTALS would now accumulate retrograde workloads as part of its internal processing. Additional factors will be requested from the transportation proponent for determination of truck unit requirements in support of retrograde workload. The model will compare the requirements for retrograde truck units with the requirement for forward moving truck units as determined by FASTALS. If a shortfall exists, additional force structure in support of retrograde movements will be generated.

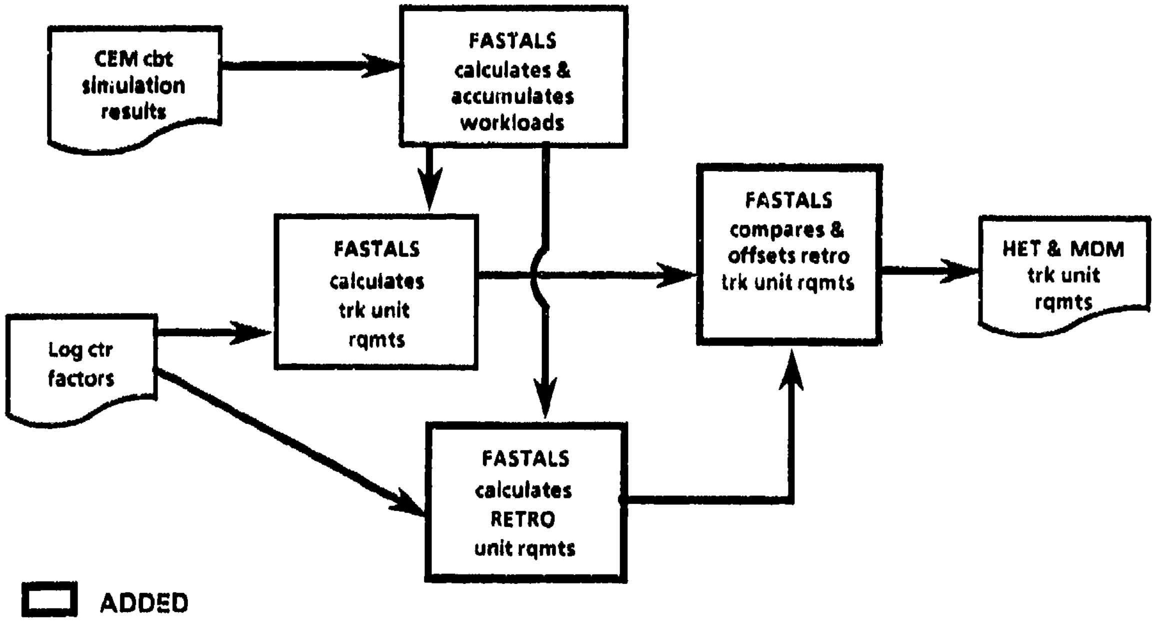


**Figure 7-3. Proposed Modification of FASTALS**

b. Internally, the FASTALS Model will generate workload as shown in Figure 7-4.

(1) The number of host nation units available is manually input under UIN 891.

(2) The total number of truck units required (UIN 892) is determined as before.

(3) The requirement for retrograde truck companies is determined (UIN 893). A new workload, workload 49, is added to the model using the methods of Chapter 5 and described in more detail in paragraph 7-7 below. Additional factors are requested from the transportation proponent that will use this workload to create a requirement for transportation units. In this example, factors similar to the ones used to create forward truck unit requirements are utilized. Factors should be similar, as rearward moving cargo will be present in the same region as the forward moving cargo. Once the total requirement for transportation units to transport retrograde materiel has been determined, the model will offset (subtract) this requirement by the net available retrograde eligible units as discussed in paragraphs 7-2 and 7-4 above. UIN 892 represents 100 percent of the units moving forward, and therefore units available for back load. In the example given in paragraph 7-4, only 75 percent of these units is available for the transport of retrograde. The model compares retrograde truck unit capability with retrograde truck unit requirements by subtracting 75 percent of the available units from the transportation requirement. If the calculation leads to a negative or 0 result, all retrograde requirements have been satisfied, and no

further action takes place involving retrograde. The addition of dummy retrograde medium truck companies to FASTALS may require renumbering of UINs.

(4) The requirements for US medium truck companies are generated as described in paragraph 7-5 with one change. In the event the retrograde requirements of paragraph 7-6b(3) create a positive number, that number is added to the requirement for US medium truck units. The host nation offset still occurs and may again eliminate any requirement for truck companies in support of retrograde. In the event that the additional truck unit requirement generated by retrograde does increase the overall truck unit requirement, FASTALS will continue its processing as usual, creating units in support of the additional truck units as required.

**CALCULATION OF LR2 MDM TRUCK CGO (55728L1) REQUIREMENTS:**

| UIN | UNIT | BASIS FOR EXISTENCE |
|---|---|---|
| 891 | HN MDM TRK CO | MANUAL INPUT |
| 892 | DUMMY MDM TRK CO | .074 PER WKL 18* IN LR1<br>.044 PER WKL 18 IN LR2 |
| 893' | DUMMY RETRO MDM TRK CO | .074 PER WKL 49** IN LR2 TO LR3<br>.074 PER WKL 49 IN LR1 TO LR2<br>- .75 PER UNIT 892 *** |
| 894 | US MDM TRK CO | - 1 PER UNIT 891<br>+ 1 PER UNIT 892<br>+ 1 PER UNIT 893 (ADDED) |

* WKL 18 — 1000 STON HOURS DRY CARGO & UNIT EQUIP / TRUCK / DAY
** WKL 49 — 1000 STON HOURS RETROGRADE CARGO TO MOVE PER DAY
*** ADJUSTMENT FOR OTHER REARWARD MOVEMENTS

Figure 7-4. Proposed Modification of FASTALS

## 7-7. DETERMINATION OF WORKLOAD

**a.** Chapter 5 gives a method of creating transportation workload offline using a microcomputer. There are two ways this workload can be incorporated into FASTALS so that the process described in paragraph 7-6 can take place. The workloads can be manually input into FASTALS, or a factor can be derived offline which can be input into FASTALS to create the workload.

**b.** The simplest approach would be to calculate the workloads as described in Chapter 5 on a microcomputer and simply manually input the workloads and run FASTALS. FASTALS can be changed to accept the two new workloads required to create medium truck and heavy truck units. Unfortunately, new workloads need to be developed for each scenario. This is wasteful in time and limits flexibility.

c. A better approach would be to take the workload developed in Chapter 5 and determine conversion factors by comparing end item density to shortfall for that item as shown in Figure 7-5.

(1) There would be two factors for each end item studied . One would be short tons per item density, and the other items per item density. Multiplying these factors by item density would create for that end item two transportation workloads--short tons (medium truck unit requirements) and items (heavy truck unit requirements).

(2) FASTALS would have to be changed to accumulate end item density on a logical region basis. At present, FASTALS does not have data on equipment authorized by individual units. This data can be obtained by changing the masterfile to accept the data.

(3) FASTALS could then use item density and the factors to create the shortfall in short tons and items for each end item by logical region over time.

(4) Adding individual end item shortfalls together gives a total shortfall for each logical region accumulated in two new workloads, 49 and 50, as shown in Figure 7-6.

(5) The remainder of the process continues as described in paragraph 7-6.

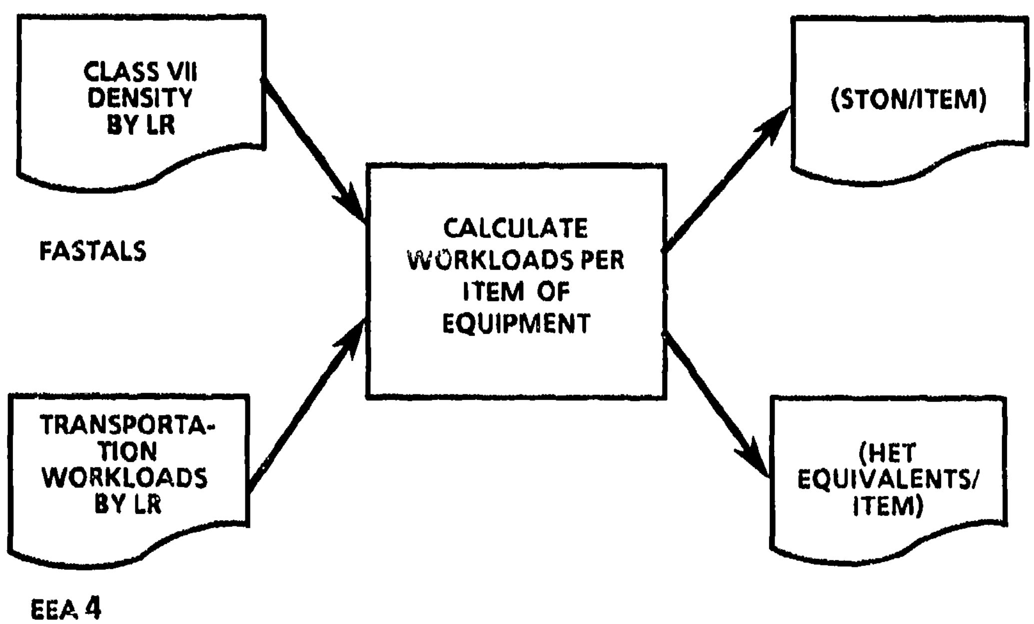


Figure 7-5. Factor Determination

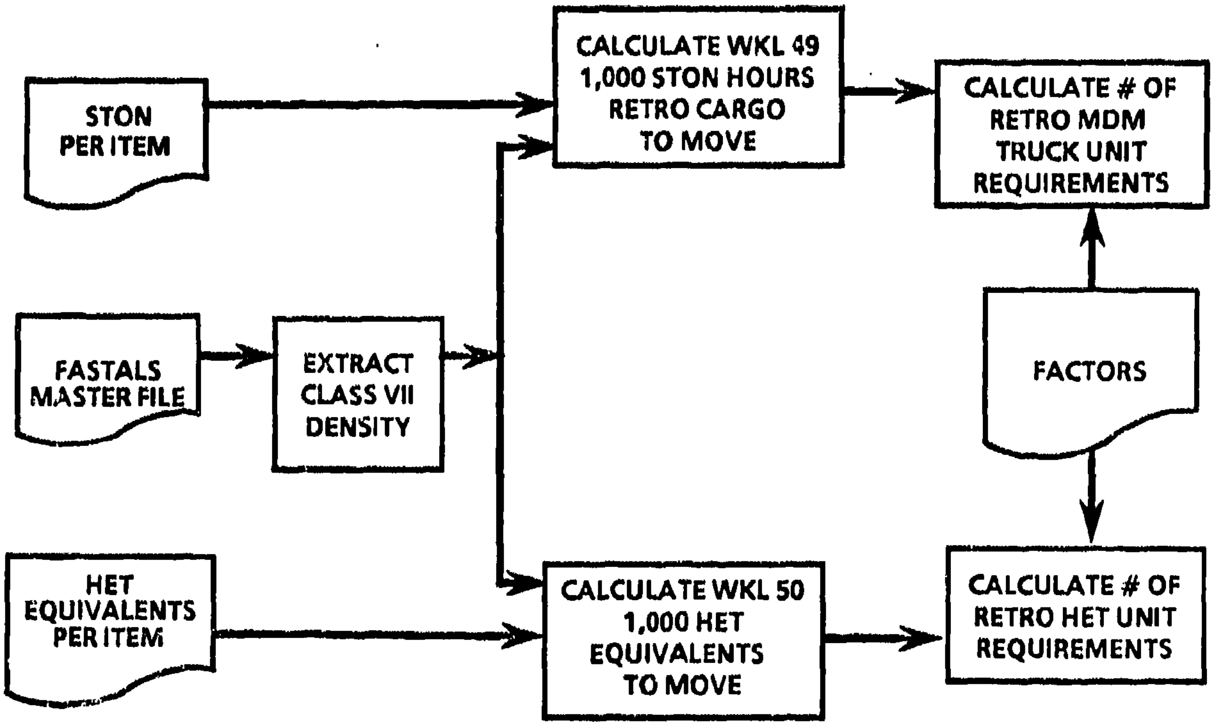


Figure 7-6. Retrograde Unit Requirements

7-8. **SUMMARY.** This chapter has presented a methodology for incorporating the transportation workloads generated by the retrograde of damaged materiel into the force structure process. In so doing, the following changes to FASTALS were proposed:

- Two additional workloads be added; one based on STON to be moved and the other based on heavy equipment to be transported.
- The master file be modified to include equipment densities for each unit.
- Some renumbering of UINs may occur as a result of these changes.
- Coding changes to:
  - -- Accumulate equipment densities.
  - -- Accept new factors to create retrograde workloads.
  - -- Calculate retrograde workloads using the factors.

# CHAPTER 8

## FINDINGS AND OBSERVATIONS

**8-1. PURPOSE.** The purpose of this chapter is to address the essential elements of analysis required of this study, summarize the key findings and observations, and summarize the study.

**8-2. ESSENTIAL ELEMENTS OF ANALYSIS (EEA).** The study directive stated six EEA which are given below with a summary of the responses resulting from the study.

**a. How can the maintenance workload which drives retrograde requirements be quantified?**

**Answer:** By using the outputs from the CEM in combination with factors from the AMSAA, maintenance workloads in terms of components and end items can be determined. Similar data will have to be requested from AMSAA for equipment of interest prior to the start of any new studies based on the methodology provided. The restrictions placed on the use of the data should be observed. Clear agreement must be reached on the meaning of each of the data elements provided.

**b. How can the wartime maintenance capability to handle retrograde-candidate materiel be quantified?**

**Answer:** Maintenance capability can be determined by multiplying units on hand, unit effectiveness, the number of personnel by MOS and the number of effective hours per MOS per day by area, respectively. If desired, unit capabilities can be adjusted based on unit readiness as is presently done to combat service support units within OMNIBUS.

**c. How can those maintenance shortfalls which generate retrograde transportation requirements be determined?**

**Answer:** Maintenance requirements by priority are compared to maintenance capability (see a and b above). Any resulting shortfall in capability will be defined as an evacuation/retrograde requirement. Prior to the start of any study utilizing this methodology, agreement must be reached as to priority of repairs between end items and components with the study sponsor.

**d. How can the requirement to move retrograde materiel be included in the transportation workload within the theater?**

**Answer:** Retrograde requirements (shortfall), as created in the previous EEA, are converted into workloads (STON or end items). End items that do not require a HET for transport and damaged components are converted to short tons for movement by medium truck units. End items requiring HETs for movement will make up the transportation workload requirements for HET units.

e. **How can wartime retrograde transportation requirements other than Class VII and IX maintenance shortfalls be estimated?**

**Answer:** Transportation workloads can be estimated for enemy prisoners of war, unit moves, medical evacuation, killed in action and mail using FASTALS, OMNIBUS, TOE files, and Field Manual 101-10-1. Rearward movement of supply stocks, captured enemy materiel, critical strategic materials, and materiel involved in denial operations cannot be estimated at this time. It is assumed that rearward movement of ammunition will be handled by those trucks not being utilized for retrograde on the basis of the assumption of paragraph 1-7d.

f. **How can the retrograde of materiel be represented in the present force structure?**

**Answer:**

- Forward moving units will move retrograde when returning from a mission. The performance of this dual mission may have a negative impact on a transportation unit's primary mission capability. Delays due to offloading/loading, speed differentials, and location of the cargo are inevitable.

- Net retrograde transportation capability is determined by decrementing the total number of forward moving units by dedicated transportation units (ammunition as excluded by assumption 5) and the negative impact of the dual mission on the remaining units.

- Net transportation capability is further reduced by adjusting capability of transportation assets for requirements generated by other rearward moving materiel and personnel.

- Total retrograde requirements are determined in terms of transportation units required to support the mission.

- Retrograde truck unit requirements are then offset by the net adjusted forward movement capability. Any shortfall in unit capability will generate an additional truck unit requirement into the force structure.

## 8-3. FINDINGS AND OBSERVATIONS

**a.** As a result of the Retrograde I Study, there is a heightened awareness of the need for more guidance in the area of retrograde movement of damaged materiel. It is expected that additional guidance will be made available in the near future. At present, that guidance is not available, making it difficult to plan for or analyze retrograde actions.

b. The current methods of determining combat damage within the model used to determine combat service support structure need to be expanded to include more systems. CEM currently damages and kills only tanks and armored personnel carriers. Damage data is collected and extrapolated to produce results for other damaged equipment. Models need to be expanded to realistically portray equipment damage including combat damage to combat service equipment located in rear areas.

c. Unit maintenance requirements as presently calculated are accumulated based on manhours per unit. Each unit in the force structure has been assigned a number of maintenance manhours by category that are accumulated by FASTALS. These manhours are provided after careful consideration by technical experts familiar with all aspects of the system's operation. In determining these manhours, the density of the equipment within individual units is an important factor. Presently, equipment density of units is not included in any of the FASTALS outputs. Logistical studies, to include the Retrograde Transportation Study, frequently have need for equipment density data. At this time, there is no way within FASTALS to tie manhours to the density of equipment that generated those manhours.

d. The methodology described in this study could be used to incorporate other combat service support functions not presently modeled. The simple approach described in Chapter 6 of using factors to detract from or add to unit capability can be used within FASTALS to improve the representation of reality. For example, suppose maintenance units were only 40 percent effective under snow conditions. If the simulation played weather on those days when snow is present, more maintenance units would be required.

**8-4. STUDY SUMMARY.** This study has proposed a method for incorporating the retrograde of damaged materiel within a theater of operations into the combat service support force structure process.

# APPENDIX A

## STUDY CONTRIBUTORS

1. STUDY TEAM

a. Study Directors

Major Richard G. Poulos, Force Systems Directorate
Captain Arnethia B. Murdock, Force Systems Directorate

b. Team Member

Mr. Stuart Davis

c. Other Contributors

Ms. Elizabeth Pyle
Publication Support Branch

2. PRODUCT REVIEW BOARD

Mr. Joseph Koletar, Chairman

Mr. George Stoll

Mr. James Wantland

Ms. Christina Quach

3. EXTERNAL CONTRIBUTORS

Mr. Jeff Landis, US Army Materiel Systems Analysis Activity
Mr. Clarke Fox, US Army Materiel Systems Analysis Activity
Mr. Gerald Nielson, US Army Materiel Systems Analysis Activity

# APPENDIX B

## STUDY DIRECTIVE

**DEPARTMENT OF THE ARMY**
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, D.C. 20310-05

DALO-PLF

27 MAR 1987

MEMORANDUM FOR DIRECTOR, U.S. ARMY CONCEPTS ANALYSIS AGENCY,
8120 WOODMONT AVENUE, BETHESDA, MD 20814-2797

SUBJECT: Retrograde Transportation (RETRO II)

1. PURPOSE OF STUDY DIRECTIVE. This directive provides tasking, direction, and guidance for a study to develop a methodology for determining the requirements and capabilities of the wartime transportation system to support the retrograde of nonoperational Class VII and IX assets within the theater of operations.

2. BACKGROUND. The Army Materiel Command (AMC) by doctrine is required to provide backup direct support and general support maintenance for those items that cannot be repaired in the theater of operations due to a shortfall in maintenance capability. Recent studies, such as Estimation of FY 86 Workloads for CONUS Wholesale Logistics Base (ESTIMATE 86) have provided estimates as to what that shortfall might be in terms of man hours by commodity. Retrograde materiel which cannot be repaired within the theater must be transported to a port area for eventual movement to CONUS or another offshore location. Movement of retrograde materiel will have an impact on the current intratheater transportation system. At the present time, a method of estimating the impact of retrograde on the transportation system does not exist.

3. STUDY SPONSOR AND SPONSOR'S STUDY DIRECTOR. HQDA, Office of the Deputy Chief of Staff for Logistics (ODCSLOG) is the study proponent. The Chief, Logistics Concepts and Doctrine Division (DALO-PLF), COL Maxie, is the proponent's study sponsor. LTC Copple is the sponsor's coordinating point of contact.

4. STUDY AGENCY. U.S. Army Concepts Analysis Agency (CAA).

5. TERMS OF REFERENCE.

a. Scope. The study will develop a methodology for examining the transport of retrograde materiel within the European theater of operations during the first 90 days of war.

b. Objective. Develop a methodology for estimating the impact of materiel retrograde on wartime intratheater transportation system requirements. The methodology should be readily adaptable for inclusion in the Total Army Analysis (TAA) Force Structure requirements process.

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c. Time frame. TAA 96.

d. Assumptions.

(1) Army Force Planning Data and Assumptions are valid.

(2) Retrograde operations will begin on D-Day.

(3) Host Nation Support will be provided as planned.

(4) Priority of items to be retrograded will not significantly affect total retrograde transportation requirements.

(5) Corps Transportation units transporting ammunition are dedicated to ammunition only by MOADS or MOADS/PLS doctrine.

(6) Railroad support is not forward of corps.

e. Study Limitation. Requirements for the retrograde of ammunition will not be considered except as implied under assumption 5 above.

f. Essential Elements of Analysis (EEA).

(1) How can the maintenance workload which drives retrograde requirements be quantified?

(2) How can the wartime maintenance capability to handle retrograde-candidate materiel be quantified?

(3) How can those maintenance shortfalls which generate retrograde transportation requirements be determined?

(4) How can the requirement to move retrograde materiel be included in the transportation workload within the theater?

(5) How can wartime retrograde transportation requirements other than Class VII and IX maintenance shortfalls be estimated.

(6) How can the retrograde of materiel be represented in the present force structure process?

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SUBJECT: Retrograde Transportation (RETRO II)

6. RESPONSIBILITIES.

a. The study proponent, ODCSLOG (DALO-PLF), will:

(1) Provide a study coordinator.

(2) Schedule In-Process Reviews (IPRs) as required.

(3) Assure that authoritative support, coordination, and required logistic data are available from DA staff elements and major command elements responsible for retrograde materiel, particularly the Military Traffic Management Command, 21st Theater Army Area Command, 200th Theater Army Area Materiel Management Center, 4th Transportation Command, and the Army Materiel Command.

b. The study agency, CAA will:

(1) Designate a study director and establish a study team.

(2) Establish direct communications with ODCSLOG and other agencies as required for conduct of the study.

(3) Provide IPR as requested by study proponent.

(4) Provide final study documentation.

7. LITERATURE SEARCH.

a. The following studies are relevant to this study effort.

(1) Army Force Planning, Data and Assumptions.

(2) Estimation of Workloads for CONUS Wholesale Logistics Base.

(3) Estimate of FY 86 Workloads for CONUS Wholesale Logistics Base.

(4) Support Force Requirements Analysis 1986.

(5) U.S. Army Operational Readiness Analysis.

(6) Transportation Improvements Program.

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(7) Analysis of Logistics Factors.

(8) Wartime Retrograde of Damaged Materiel from a Theater of Operations.

8. REFERENCES.

a. The following Army publications are applicable to this study:

(1) AR 5-5, Army studies and Analysis, 15 Oct 81.

(2) AR 10-38, U.S. Army Concepts Analysis Agency, 18 Dec 85.

(3) Army Force Planning Data and Assumptions, Aug 87.

9. ADMINISTRATION.

a. Funds. Funds required for TDY, per diem, etc., are the responsibility of each participating organization.

b. ADP. Data processing requirements, other than copies of required data files, will be provided by the study agency.

c. Control Procedures.

(1) The study proponent will arrange for IPR as required.

(2) Milestones.

(a) Draft study report to proponent 1 Jul 89.

(b) Proponent's draft report review comments to CAA 1 Aug 89.

d. The study agency will prepare and update the Research and Technology Work Unit Summary (DD Form 1498).

e. The study proponent will prepare a written evaluation of the study results IAW AR 5-5.

DALO-PLF
SUBJECT: Retrograde Transportation (RETRO II)

f. This study directive complies with the mission, functions, and procedures of the U.S. Army Concepts Analysis Agency and has been coordinated in accordance with paragraph 6, AR 10-38.

FOR THE DEPUTY CHIEF OF STAFF FOR LOGISTICS:

WILLIAM G. PAGONIS
Brigadier General, GS
Director of Plans
and Operations

# APPENDIX C

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Patient Flow Model (PFM), CAA-D-82-1 (Rev), March 1984

Army Force Planning Data and Assumptions, FY 1988-97 (AFPDA FY 88-97), August 1987

User's Manual for Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS) (Rev), June 1988

# APPENDIX D

## DESCRIPTION OF FASTALS PROCESS

MODEL DESCRIPTION. The purpose of the Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS) Model is to compute administrative and logistical workloads and to generate the theater-level support force structure necessary to round out a combat force in a postulated confrontation. FASTALS, a requirement model, may be used in any force planning simulation to develop a force that is balanced, time-phased, and geographically distributed. A trooplist is said to be balanced when the individual units comprising the list are capable of accomplishing the various workloads generated by the total force. Trooplists are said to be time-phased when unit requirements are prescribed for each time period in the simulation. The major elements of support are maintenance, construction, supply, transportation, hospitalization and evacuation, and personnel replacement.

Major DA studies utilizing FASTALS include the Total Army Analysis (TAA), OMNIBUS, and the Joint Strategic Planning Document Analysis (JSPDA). The model is also used in excursions to assess the impact of force modernization, logistic initiatives, and host nation support contributions on US force structure requirements.

INPUTS - Each study has its own set of data files for each theater examined. The data must reflect the force being portrayed on the force tape, which has been prepared by the study proponent. The two major input files are described.

- MASTERFILE (MF). This file contains data necessary to allocate units and to prescribe unit support requirements. Key entries include:

-- Logical Region (LR). Reflects a unit's normal area of operation in the theater (1-division, 2-corps, 3-rear combat zone, 4-COMMZ, 5-ports, 6-offshore). LRs are further delineated into three sectors which divide the LRs into horizontal borders. For example, in NATO the three sectors generally represent NORTHAG (sector 1) and CENTAG (sectors 2 and 3).

-- Manpower Requirement Criteria Data (MACRIT). Represent daily manhours of automotive (DS, GS), power generation, aircraft, and other types of maintenance needed to maintain the equipment in each unit, and which is above the unit's organic capability to perform.

-- Allocation Rules (AR). The most critical of all MF data. An AR is a statement of a unit's capability, mission, and/or doctrinal employment and, in conjunction with other data, determines how many of a certain type unit will be reflected in the final trooplist of requirements. All rules are coordinated with the study sponsor and the TRADOC community. Three types of AR exist:

1) Manual Entry - Units are placed directly into the scenario by time period and location. Almost all combat units are entered manually, as are a limited number of CS/CSS units that have a special mission or fixed quantity (i. e., petroleum pipeline companies that operate emergency pipelines in accordance with certain contingency plans).

2) Existence Rule - Units are allocated based on the existence of some other units(s) in the theater. This allows the theater to be rounded out in accordance with normal TOE doctrine.

3) Workload Rule - Units are allocated based on the capability to accomplish generated workloads.

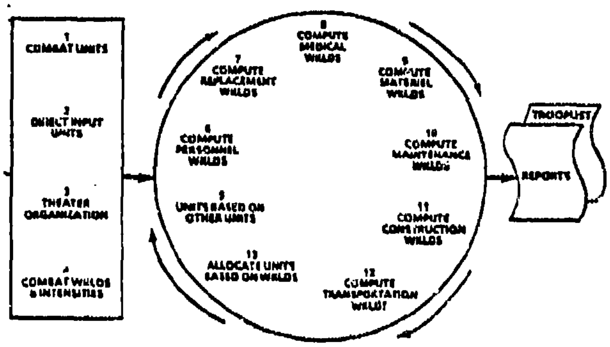
Other data found in the MF include standard requirement codes, units descriptions, strengths, and weights of the units.

- SCENARIO. This data set represents the major variable inputs which, when combined with the MF, generates the statement of support force requirements.

-- Combat simulation Data. The combat data required to run FASTALS include unit location and employment time, level of combat intensity, ammunition consumption, damaged and repairable tanks/APCs, casualties, and changes in FEBA.

-- Other data provided include a layout of the theater's geographical structure; number of forward deployed and POMCUS units; PWRMS, stockage policy, and supply data; engineer construction policy; and transportation data representing links, paths, and capacities for each mode (highway, railroad, waterway, pipeline).

EXECUTION - First, the combat units employed by the combat model are augmented by direct input units and by units that are implied by the organizational structure of the theater being analyzed (e. g., number of corps). Next, units that are required on the basis of the existence of other units in the theater are added to the list. The model then computes workloads generated by these units in terms of personnel replacements, hospital admissions, supplies, maintenance, construction, and transportation. These workloads are then used as a basis for adding units such as hospitals and medium truck companies. This new set of units generates another increment, and so the cycling process begins. Additional units increase the workloads which, in turn, generate a requirement for more units. This cyclic process , steps 5 through 13 in figure, continues until the model computes the same set of units (trooplist) that was computed on the previous cycle (requirements converge).




FASTALS LOGIC FLOW

OUTPUTS - The principle output produced is the time-phased troop deployment list of theater requirements. Other reports provide consumption and stockage requirements for each category of supply. Additional reports include 48 workload summaries that relate to personnel replacements, medical, materiel, maintenance, construction, transportation, and casualties.

# APPENDIX E

## AMSAA DATA

**DEPARTMENT OF THE ARMY**
U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
Aberdeen Proving Ground, Maryland 21005-5071

REPLY TO ATTENTION OF
AMXSY-LM (70)

13 JUL 1989

MEMORANDUM FOR Director, Concepts Analysis Agency, ATTN: CSCA-MVD, Bethesda, MD 20814

Subject: Data Package for Retrograde Transportation (RETRO II) Study

1. Reference: CSCA-MVD, Memorandum, SAB, 7 April 1989.

2. The data requested in above reference to support the RETRO II Study are enclosed.

3. It is understood by AMSAA that these data will be used in the RETRO II Study, specifically as an estimate of the weight and quantity of reparable parts to be repaired off-item, and the manhours associated with the removal and repair of these parts.

4. The data provided in enclosure 1 are the mean man hours for on and off item repair, and repair part quantity and weight for three systems: the M1A1, the M2 and the M109. Distributions are also given for echelon of repair and for type of subsystem repaired (automotive, firepower or missile). The man hour and part quantity data were derived from MARC data. The part weight results were taken from Field Exercise Data Collection information for the organizational and DS echelons, and from the Candidate Item File for the GS echelon. Note that the part weights are mean values for a single part. Also note that the man hour and part quantity data are averages for a single maintenance action. These values may require adjustment if the scenario and/or model in which they are used imply multiple actions per maintenance visit (i.e., multiple actions per system down for maintenance).

5. The data provided in enclosure 2 are the mean man hours for repair and repair part quantity for combat damage for four systems: the M1, the M2, the AH-64, and the M109A2. The information is broken down by echelon of repair (ORG, DS, and GS; or AVUM and AVIM for the aircraft) and by type of subsystem repaired (automotive, firepower, or missile). The part quantity is based on information from the SPARC data base. Repair times are based on SPARC data and Maintenance Allocation Charts.

6. In compliance with HQ AMC policy, signature of this letter indicates certification by the head of this Activity, the Deputy Director or designated GO/SES that:

a. The data are the best available within time and resource constraints.

b. The caveats and limitations of the data concerning the conditions under which they were generated are clearly stated. For example, conditions

AMXSY-LM
SUBJECT: Data Package for Retrograde Transportation (RETRO II) Study

for which they apply (day or night, stationary or moving target, target size, under which conditions substitutions have been made, etc).

c. To the best of the data providers' knowledge these data are appropriate for the intended application within the limitations and caveats stated.

7. These data may not be used in any other model or to support other analytical efforts without prior approval (in writing) from the certification authority.

8. The POC for this request is Gerald Nielsen, AV 298-4974.

FOR THE DIRECTOR:

2 Encls
as

John J. McCarthy
JOHN J. McCARTHY
Chief, Logistics & Readiness
Analysis Division

CF:
AMC, ATTN: AMCAE (Dr. C. Chapin) w/o encl
AIA, ATTN: AIAIT-M (Mr. M. Carroad) w/ encl
TRAC-Monroe, ATTN: ATRC-RPP (Mr. Dempsey) w/encl

T13168 M1A1

| | Mean Man Hours | | | | | | | | Parts | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ON | | | | OFF( 87.8%) | | | | QUAN | | | WGHT(lbs) | | | |
| Level | % | a | f | m | % | a | f | m | a | f | m | a | f | m |
| UNT | 86.1 | 4.1 | 9.8 | - | 0.0 | - | - | - | 1.6 | 1.0 | - | 60 | 65 | - |
| MST | 12.1 | 5.1 | 10.4 | - | 0.0 | - | - | - | 1.1 | 1.6 | - | 3582 | 98 | - |
| MDS | 0.0 | - | - | - | 95.8 | 3.9 | 2.0 | - | - | - | - | - | - | - |
| GS | 1.8 | 1.7 | 1.6 | - | 4.2 | 19.1 | 3.5 | - | 1.3 | 1.1 | - | 428 | 6 | - |
| Subsys%: | | 25.8 | 74.2 | 0.0 | | 8.1 | 91.9 | 0.0 | | | | | | |

[1.4 actions per visit]

K57667 M109

| | Mean Man Hours | | | | | | | | Parts | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ON | | | | OFF( 38.6%) | | | | QUAN | | | WGHT(lbs) | | | |
| Level | % | a | f | m | % | a | f | m | a | f | m | a | f | m |
| UNT | 77.7 | 3.2 | 3.7 | - | 0.0 | - | - | - | 1.3 | 1.3 | - | 83 | 125 | - |
| MST | 17.1 | 11.0 | 6.2 | - | 0.0 | - | - | - | 1.3 | 1.3 | - | 944 | 69 | - |
| MDS | 0.0 | - | - | - | 79.8 | 1.6 | 4.6 | - | - | - | - | - | - | - |
| GS | 5.2 | 8.5 | 5.4 | - | 20.2 | 12.6 | 2.3 | - | 1.3 | 1.3 | - | 18 | 1 | - |
| Subsys%: | | 70.3 | 29.7 | 0.0 | | 79.9 | 20.1 | 0.0 | | | | | | |

[1.3 actions per visit]

J81750 M2

| | Mean Man Hours | | | | | | | | Parts | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ON | | | | OFF( 17.2%) | | | | QUAN | | | WGHT(lbs) | | | |
| Level | % | a | f | m | % | a | f | m | a | f | m | a | f | m |
| UNT | 85.2 | 5.3 | 4.0 | - | 0.0 | - | - | - | 2.0 | 1.0 | - | 52 | 105 | 77 |
| MST | 14.7 | 10.7 | 7.9 | 11.9 | 0.0 | - | - | - | 1.1 | 1.3 | 1.4 | 2264 | 520 | 75 |
| MDS | 0.0 | - | - | - | 84.8 | 3.1 | 3.5 | - | - | - | - | - | - | - |
| GS | 0.1 | 41.9 | 4.1 | 5.0 | 15.2 | 36.8 | - | - | 5.4 | 2.0 | 1.0 | 835 | 1 | 1 |
| Subsys%: | | 53.9 | 40.9 | 5.2 | | 51.2 | 48.8 | 0.0 | | | | | | |

[1.3 actions per visit]

These data are broken down by echelon, on or off item repair, and subsystem type (automotive, firepower or missile). For example, the M1A1 shows 4.1 manhours average per organizational automotive action, and, of the on-item actions, 86 percent occur at the unit level. Similarly, 74 percent of the on-item actions are on firepower components. The probability that an on item action leads to an off-item action is 0.878, as shown by the value in parentheses. Only 4.2 percent of the off-item actions occur at the GS level, and an automotive action at the GS level averages 19.1 manhours. The man hour and part quantity results were derived from MARC data. An average of 1.6 automotive parts are repaired off-item for the M1A1 at the unit level, and these parts weigh an average of 60 pounds each. These part weights were derived from the Field Exercise Data Collection Program. Only parts coded essentiality C and recovery code reparable were included in these means, and only the top 100 parts by frequency.

Note that the M109 part quantities were taken from an FEDC publication: FEDC-SPR-3-88, Automotive System Failure Rates, specifically, from the average number of essential parts per action.

The FEDC results do not allow a direct calculation of the weight of an average GS off-item repair part, because GS echelon is not included in the collection effort. Our current best estimate for these weights is taken from the Candidate Item File, weighting each part weight by the failure rate and the echelon removal and repair rates.

A further example may be helpful in applying these results. Begin with 1000 maintenance actions by M1 tanks. Of these 1000, 860 would be at the org level. Of the 860, 222 would be automotive actions (860 X 0.258). Thus, 910 man hours would be expected for automotive actions at unit level (222 X 4.1). From conversations with MAJ Poulos, it is understood that his retrograde model determines a total workload for each echelon of maintenance. The retrograde parts movement is considered to be caused by maintenance actions beyond the capacity of support. Unfortunately, the identity of the originating actions is lost, so that an alternate means of estimating quantity and weight of retrograded parts is needed. It is suggested that overflow actions be attributed to the originating echelon and subsystem category in the same manner as the originating actions: according to the marginal distributions. If greater accuracy is necessary, a more detailed model should be explored, which could retain the identity of the originating maintenance actions.

Note that FEDC results show approximately 1.4 actions per maintenance visit for the M1A1. This number could be used as an adjustment factor if the model being used is driven by maintenance visits instead of actions.

The following is a list of MOS types which was used to stratify MARC data according to automotive, firepower or missile subsystem. The MOSs are listed in alphabetical order, and the accompanying letter indicates the associated subsystem: (a) automotive, (f) firepower, (m) missile.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13M | m | 13MS8 | m | 13N | m | 24C | m | 24E | m | 24F | m | 24G | m | 24H | m |
| 24J | m | 24K | m | 24L | m | 24M | m | 24MX7 | m | 24N | m | 24T | m | 24TT5 | m |
| 24U | m | 24Y | m | 27E | m | 27ED3 | m | 27ED3 | m | 27G | m | 27L | m | 27M | m |
| 27N | m | 27U | m | 29E | m | 31V | m | 41C | f | 44B | a | 45D | f | 45E | f |
| 45G | f | 45K | f | 45L | f | 45N | f | 45T | f | 52C | m | 52F | m | 63B | a |
| 63D | a | 63E | a | 63G | a | 63H | a | 63N | a | 63S | a | 63T | a | 63W | a |
| 63Y | a | | | | | | | | | | | | | | |

M1 - MAIN BATTLE TANK

| | Mean Man Hours | | | Parts | | |
|---|---|---|---|---|---|---|
| Echelon | a | f | m | a | f | m |
| ORG 28% | 9.44 | 10.28 | 0.00 | 3.83 | 4.47 | 0.00 |
| DS 67% | 23.93 | 36.76 | 0.00 | 4.42 | 7.90 | 0.00 |
| GS 5% | 43.84 | 74.66 | 0.00 | 5.12 | 7.22 | 0.00 |
| | 44% | 56% | 0% | | | |

M2 - BRADLEY FIGHTING VEHICLE, INFANTRY (IFV)

| | Mean Man Hours | | | Parts | | |
|---|---|---|---|---|---|---|
| Echelon | a | f | m | a | f | m |
| ORG 29% | 5.35 | 1.83 | 0.00 | 4.48 | 2.93 | 0.00 |
| DS 68% | 11.73 | 2.06 | 0.90 | 4.30 | 3.57 | 0.72 |
| GS 3% | 12.32 | 1.39 | 0.00 | 6.78 | 2.01 | 0.00 |
| | 54% | 23% | 23% | | | |

AH-64 - APACHE ATTACK HELICOPTER

| | Mean Man Hours | | | Parts | | |
|---|---|---|---|---|---|---|
| Echelon | a | f | m | a | f | m |
| AVUM56% | 1.82 | 0.72 | 0.00 | 3.88 | 0.40 | 0.00 |
| AVIM44% | 5.18 | 0.88 | 0.13 | 3.77 | 0.48 | 0.18 |
| | 86% | 10% | 4% | | | |

M109A2 - 155MM SELF-PROPELLED HOWITZER

| | Mean Man Hours | | | Parts | | |
|---|---|---|---|---|---|---|
| Echelon | a | f | m | a | f | m |
| ORG 88% | 11.35 | 0.00 | 0.00 | 11.35 | 0.00 | 0.00 |
| DS 11% | 2.12 | 5.30 | 0.00 | 1.06 | 0.99 | 0.00 |
| GS 1% | 0.00 | 4.39 | 0.00 | 0.00 | 1.00 | 0.00 |
| | 98% | 2% | 0% | | | |

Repair times and number of parts are based on the SPARC (Sustainability Predictions for Army Spare Component Requirements for Combat) database. Only critical components are used. Critical components are those that have an Essentiality Code of A, C, or J. Parts are divided into automotive, firepower, or missile, based on their Materiel Category (MATCAT) Structure Code. Codes of E, H, J, K, Q, and T are automotive; codes of M and G are firepower; and codes of L are missile. Repair levels for the M1, M2, and M109 are determined by the Source, Maintenance, and Recoverability (SMR) Code. For the AH-64, repair times and number of parts are distributed between AVUM and AVIM based on SPARC results for the AH-64 threats against a surrogate system.

Repair times for the M1 come entirely from SPARC. However, this is not the case for the other systems. For the M2, direct fire repair times come from SPARC while those for indirect fire are based on reliability data. This is appropriate since remove and replace times for indirect fire would be similar to those for reliability failures. The AH-64 and M109 are based solely on reliability repair times.

# APPENDIX F

## DEVELOPMENT OF CONVERSION FACTORS

**F-1. INTRODUCTION.** This appendix describes the method used in determining the conversion factors appearing in Table 5-5. By using these factors, it is possible to convert a workload in manhours of damaged components into a transportation workload in short tons.

**F-2. GENERAL.** The method used in determining the factors is to reverse the calculations used in determining the workload in manhours. Following this process, it is possible to determine the total number of end items generating the shortfall. Once the end items are known, AMSAA data from Appendix E is used to determine the distribution of damaged components. Once this relationship is determined, the damaged components are multiplied by average weights to get total weight. The total weight is then adjusted to get the weight for 1 manhour.

**F-3. METHODOLOGY.** This explanation will determine the factor used for Automotive RAM components of the tank.

a. In determining the workload in manhours, the following relationships exist.

Total End Item Failures * Off Item Repair Factor =
Total Off Item Repairs

Total Off Item Repairs * RAM Failure Off Item Distribution *
Automotive Off Item Factor * Mean Manhours = Workload in Manhours

Using actual data from Appendix E and assuming 1,000 total end item RAM failures the calculations are as follows:

Total Off Item Repairs = 1,000 * .878 = 878

Workload in Manhours = 878 * .958 * .081 * 3.9 = 266

b. Any shortfall identified will be a workload in manhours. Given a workload in manhours (shortfall), it is a simple mathematical process to work backward to determine the total end item RAM failures. Reversing the process leads to the following relationships:

$$\frac{\text{(Workload in Manhours)}}{\text{(RAM Failure Off Item Distribution *Automotive Off Item Factor *Mean Man Hours)}} = \text{Total Off Item Repairs}$$

$$\frac{\text{Total Off Item Repairs (shortfall)}}{\text{Off Item Repair Factor}} = \text{Total End Item RAM Failures}$$

Using the above data, the calculations are as follows:

Table F-3. Components per End Item

| | | |
|---|---|---|
| Organizational | = | 1.6 |
| Direct support | = | 1.1 |
| General support | = | 1.3 |

Table F-4. Components

| | | |
|---|---|---|
| Organizational | = | 312 |
| Direct support | = | 30 |
| General support | = | 5 |

g. There is a direct relationship between actions performed off item and the number of damaged components that require repair. Components are not normally repaired at organizational level. From Appendix E, 95.8 percent of off item actions are DS. Therefore, to determine the amount of components from Table F-4 requiring repair at the DS level, the organizational and DS values of Table F-4 are multiplied by .958, resulting in Table F-5.

Table F-5. DS Components

| | | |
|---|---|---|
| Organizational | = | 299 |
| Direct support | = | 29 |
| General support | = | N/A |

h. Multiplying the values of Table F-5 by the average weight of components created at that level (Table F-6) produces a total weight to be transported in pounds (Table F-7). Notice that only the values for DS and organizational components were totaled. This example is working backward to determine the amount of DS component repair creating the original shortfall. GS materiel may or may not have been repaired, and would be determined by working backward from GS shortfall to determine the GS conversion factor. Note that in calculating GS, 100 percent of the GS component weights and 4.2 percent of the DS and organizational weights would be considered. DS and organizational weights are considered together because organizational components will be largely repaired at DS level.

**Table F-6. Average Weights (pounds)**

| | | |
|---|---|---|
| Organizational | = | 60 |
| Direct support | = | 3,582 |
| General support | = | 428 |

**Table F-7. Total Weight (pounds)**

| | | |
|---|---|---|
| Organizational | = | 17,940 |
| Direct support | = | 3,878 |
| General support | = | 0 |
| | | ====== |
| Total | = | 121,818 |

i. To determine the amount of damaged component shortfall to be transported in short tons, divide 121,818 by 2,000 to get 60.9 short tons. Thus, a shortfall of 266 manhours results in a movement requirement of 60.9 short tons. The movement factor of Chapter 5 is determined by dividing the 60.9 short tons by 266 to get .2289 short tons per manhour.

F-4. **SUMMARY.** This appendix has shown how, given a maintenance shortfall in manhours, that factors used for converting shortfall in manhours to shortfall in short tons can be developed.

# APPENDIX G

## SPONSOR'S COMMENTS

**DEPARTMENT OF THE ARMY**
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, DC 20310-0500

DALO-PLA 20 DEC 89

MEMORANDUM FOR CHIEF, LOGISTICS SYSTEMS DIVISION, US ARMY CONCEPTS ANALYSIS AGENCY, 8120 WOODMONT AVE, BETHESDA, MD, 20814-2797

SUBJECT: Retrograde Transportation (RETRO-II)

1. The study critique and distribution list are enclosed. This study was very well done and meets the needs of the sponsor. This office is looking forward to the results of RETRO-III.

2. Point of contact for this response is the undersigned.

FOR THE DEPUTY CHIEF OF STAFF FOR LOGISTICS:

Donald M. Feeney

Encl

DONALD M. FEENEY
Chief, Logistics Studies
and Analyses Division

# STUDY CRITIQUE

(This document may be modified to add more space for responses to questions.)

1. Are there any editorial comments? NO If so, please list on a separate page and attach to the critique sheet.

2. Identify any key issues planned for analysis that are not adequately addressed in the report. Indicate the scope of the additional analysis needed. Scope contained in RETRO III Study Directive; prove the worth of this methodology in the next SRA process.

3. How can the methodology used to conduct the study be improved?

The methodology appears sound. No recommendations can really be made until results of RETRO III are known.

4. What additional information should be included in the study report to more clearly demonstrate the bases for the study findings?

None. This report is very technical and must be just by the nature of the study.

5. How can the study findings be better presented to support the needs of both action officers and decisionmakers? The material is very clearly presented for those familiar with the subject area. For those who are not, there is no way to present it more clearly.

6. How can the written material in the report be improved in terms of clarity of presentation, completeness, and style? Answer to 5 above applies

## STUDY CRITIQUE (continued)

7. How can figures and tables in the report be made more clear and helpful? Eliminate reproduction of computer output in the report which are deemed figures. Figure 6-4 is an example.

8. In what way does the report satisfy the expectations that were present when the work was directed? The report logically approaches the problem of accumulating workload that should be used in computing transportation requirements.

In what ways does the report fail to satisfy the expectations?
It satisfies expectations and can be used as a tutorial for those new to the force structuring/modelling world.

9. How will the findings in this report be helpful to the organization which directed that the work be done? It will help in better understanding the force structuring process and in developing improved workload data for transportation units.

If they will not be helpful, please explain why not.
N/A

10. Judged overall, how do you rate the study? (circle one)

Poor Fair Average Good Excellent

# APPENDIX H

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# GLOSSARY

## 1. ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

| | |
|---|---|
| AFPDA | Army Force Planning Data and Assumptions (study) |
| ALOGFACS | Analysis of Logistics Factors (study) |
| AMC | US Army Materiel Command |
| AMSAA | Army Materiel Systems Analysis Agency |
| APC | armored personnel carrier |
| AR | Army regulation; armor; Armor (branch) |
| ARB | Analysis Review Board |
| ARSTAF | Army Staff |
| bde | brigade |
| bn | battalion |
| CAA | US Army Concepts Analysis Agency |
| cbt | combat |
| CG | commanding general |
| CINCUSAREUR | Commander in Chief, United States Army, Europe |
| co | company |
| comd | command |
| COMMO | communications |
| COMMZ | communications zone |
| COMPO | component code<br>1 - Active Army<br>2 - National Guard<br>3 - Army Reserve<br>4 - Recognized shortfall (unmanned/unresourced units)<br>5 - FASTALS-generated shortfall<br>6 - Mobilization requirements not included in COMPO 4<br>7 - Direct HNS<br>8 - Indirect HNS<br>9 - Contingency contract offset |
| CONUS | continental United States |

| | |
|---|---|
| COSCOM | corps support command |
| CS | combat support; composite service |
| CSA | Chief of Staff, US Army |
| CSS | combat service support |
| CTA | common table of allowances |
| DA | Department of the Army |
| DCSLOG | Deputy Chief of Staff for Logistics |
| DCSOPS | Deputy Chief of Staff for Operations and Plans |
| D-day | day on which operation commences, or is due to commence |
| DIH | died in hospital |
| DISCOM | division support command |
| div | division |
| DNBI | disease and nonbattle injuries |
| DOD | Department of Defense |
| DOW | died of wounds |
| DS | direct support |
| EAC | echelon(s) above corps |
| EAD | echelon(s) above divisions; earliest arrival date |
| EEA | essential element(s) of analysis |
| EPW | enemy prisoner(s) of war |
| equiv | equivalent |
| evac | evacuate; evacuated; evacuation |
| FAS | Force Accounting System |
| FEBA | forward edge of the battle area |
| FLOT | forward line of own troops |
| FM | field manual |
| FRG | Federal Republic of Germany |

| | |
|---|---|
| Ft | Fort |
| fwd | forward |
| FY | fiscal year |
| GRREG | graves registration |
| GS | general support |
| HEMCO | heavy equipment maintenance company |
| HET | heavy equipment transporter |
| HND | host nation direct |
| HNI | host nation indirect |
| HNS | host nation support |
| HQ | headquarters |
| HQDA | Headquarters, Department of the Army |
| [illegible] | hour |
| hvy | heavy |
| IPR | In-process review |
| KCMIA | killed, captured, missing in action |
| KIA | killed in action |
| km | kilometer(s) |
| LAD | latest arrival date |
| LEMCO | light equipment maintenance company |
| LOC | line(s) of communication (logistic routes) |
| log | logistics; logistical |
| LOGCAP | logistical civil augmentation program |
| LOGCEN | US Army Logistics Center |
| LR | logical region (in FASTALS) |
| lt | light |
| M-FORCE | Army Master Force |

| | |
|---|---|
| MAC | Military Airlift Command |
| MACOM | major Army command |
| MACRIT | Manpower Requirements Criteria |
| maint | maintain; maintained; maintenance |
| MARC | Manpower Requirements Criteria |
| mdm | medium |
| MH | manhour(s) |
| MIA | missing in action |
| MOADS | Maneuver Oriented Ammunition Distributed System |
| MOS | military occupational specialty |
| MP | military police |
| MRC | Materiel Readiness Command |
| MSC | Military Sealift Command; major subordinate command |
| MSR | main supply route |
| MTMC | Military Traffic Management Command |
| NATO | North Atlantic Treaty Organization |
| NLT | not later than |
| no | number |
| ODCSLOG | Office of the Deputy Chief of Staff for Logistics |
| OMNIBUS | US Army Operational Readiness Analysis |
| Org | organization |
| ORSA | Operations Research/Systems Analysis |
| pam | pamphlet |
| pers | personnel |
| plt | platoon |
| PLS | Palletized Loading System |
| POC | point of contact |

| | |
|---|---|
| POD | port of debarkation |
| POE | port of embarkation |
| POM | program objective memorandum |
| POMCUS | prepositioning of materiel configured to unit sets |
| RAM | reliability; availability; and maintainability |
| RCZ | rear combat zone |
| RDD | required delivery date |
| REFORGER | return of force to Germany |
| RETRO | regrograde |
| RIH | remain in hospital |
| SOP | standard operating procedure |
| SPOD | seaport of debarkation |
| SPOE | seaport of embarkation |
| SRA | Support Force Requirements Analysis |
| SRC | standard requirement code |
| STON | short ton(s) |
| TA | theater Army |
| TAA | total Army analysis; Total Army Analysis (study) |
| TAACOM | Theater Army Area Command |
| TDA | table(s) of distribution and allowances |
| TOE | table(s) of organization and equipment |
| TPFDD | Time-Phased Force Deployment Data |
| TPFDL | Time-Phased Force Deployment List |
| TRADOC | US Army Training and Doctrine Command |
| trans | transportation |
| trk | truck |
| UDS | unit data system |

| | |
|---|---|
| UIC | unit identification code |
| UIN | unit identification number |
| USAF | US Air Force |
| USALOGC | US Army Logistics Center |
| USAMSAA | US Army Materiel Systems Analysis Activity |
| USAREUR | United States Army Europe |
| WIA | wounded in action |

## 2. TERMS UNIQUE TO THIS STUDY

| | |
|---|---|
| off item | Repair of components that have been removed from a piece of equipment and repaired separately |
| offset factor | The percentage of rearward moving truck units not available for transport of retrograde |
| on item | All repairs occurring on a piece of equipment without removal |
| other rearward movements | Movements other than retrograde moving rearward in a theater of operations which compete with retrograde for scarce transporation assets |

## 3. MODELS, SIMULATIONS, AND ROUTINES

| | |
|---|---|
| CEM | Concepts Evaluation Model - a low-resolution, computerized, theater-level combat model |
| FASTALS | Force Analysis Simulation of Theater Administrative and Logistic Support - a model which computes administrative and logistical workloads of a combat force and adds support units to the theater force to accomplish the support requirements of both the combat and support forces |
| PFM | Patient Flow Model |
| SPARC | Army Spare Components Requirements for Combat |
| WARMAPS | Wartime Manpower Planning System |
| WARRAMP | Wartime Requirements for Ammunition, Materiel and Personnel - a methodology for estimating combat requirements for conventional ammunition, equipment replacements, and personnel |

## 4. DEFINITIONS

**line haul**

Line hauls have a long running time compared to loading and unloading time. They normally involve one trip or a portion of a trip per operating shift. They are are evaluated on the basis of time consumed, distance traveled, and tonnage hauled during the operational period. Current planning factors from FM 101-10-1/2 are one trip per 10-hour operating shift, traveling a distance of 90 miles one way.

**local haul**

Local hauls have a short running time compared to loading and unloading time. They normally involve a number of trips per day. Current planning factors from FM 101-10-1/2 are two trips per 10-hour operating shift, traveling a distance of 20 miles one way.

**material**

The substance or substances out of which a thing is or may be constructed; composed of or pertaining to physical substances; relating to matter

**materiel**

The equipment, apparatus, and supplies, such as guns and ammunition, of a military force; the equipment, apparatus, and supplies of any organization

| | | |
|---|---|---|
| CAA | RETROGRADE TRANSPORTATION (RETRO II) STUDY | STUDY SUMMARY CAA-SR-89-18 |

**THE REASON FOR PERFORMING THE STUDY** was to develop a method of incorporating a workload (retrograde of damaged materiel within a theater of operations) not presently included in the process utilized for determining requirements for military transportation truck units within current force structure models.

**THE STUDY SPONSOR** was the Deputy Chief of Staff for Logistics, Headquarters, Department of the Army.

**THE STUDY OBJECTIVE** was to develop a methodology for estimating the impact of materiel retrograde on the wartime intratheater transportation requirements. The methodology was to be readily adaptable for inclusion in the Total Army Analysis force structure requirements process.

**THE SCOPE OF THE STUDY** was to examine the transport of retrograde materiel within the European theater of operations during the first 90 days of a potential conflict.

**THE MAIN ASSUMPTIONS** of this work are:

(1) Retrograde operations will begin on D-day.

(2) The priority of items to be retrograded will not significantly affect total retrograde transportation requirements.

(3) Corps transportation units transporting ammunition are dedicated to ammunition only by the Maneuver Oriented Ammunition Distribution System (MOADS) or MOADS/Palletized Loading System (PLS) doctrine.

(4) Railroad support is not forward of corps.

(5) Output from a combat simulation model such as the Concepts Evaluation Model (CEM) and the Force Analysis Simulation of Theatre Administrative and Logistic Support (FASTALS) Model will be available.

**THE BASIC APPROACH** used in this study was to examine the retrograde process along with models currently used to determine force structure. Results of this comparison were used to recommend changes to the force structure process that would allow the inclusion of retrograde-created transportation workloads in the process.

**THE PRINCIPAL FINDINGS** of the work reported herein are as follows:

(1) Retrograde can be included in the force structure process using maintenance data provided by current models.

(2) Combat damage determination within the models used to determine combat service support structure may need to be expanded to include more systems.

(3) Equipment densities need to be incorporated into the Force Analysis Simulation of Theater Administrative and Logistic Support (FASTALS) Model in order to support retrograde requirements determination.

(4) The methodology described in this study could be used to incorporate other combat service support functions not presently modeled in the force structuring process.

**THE STUDY EFFORT** was directed by MAJ Richard G. Poulos, Force Systems Directorate, US Army Concepts Analysis Agency (CAA).

**COMMENTS AND QUESTIONS** may be sent to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-FSL, 8120 Woodmont Avenue, Bethesda, Maryland 20814-2797.